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МАЗМҰНЫ/ CONTENTS/ СОДЕРЖАНИЕ

<i>Абақанов Т., Ли А., Садыров Р., Абақанов А.</i> Қазақстандағы сейсмикалық қауіпсіздіктің жай-күйі мен перспективалары	
<i>Abakanov T., Lee A., Sadyrov R., Abakanov A.</i> Seismic safety state and prospects in Kazakhstan	
<i>Абақанов Т., Ли А., Садыров Р., Абақанов А.</i> Состояние и перспективы сейсмической безопасности в Казахстане	8
<i>Абдығалиев А.Е., Жакулин А.С., Жакулина А.А., Тоимбаева Б.М.</i> Су қаныққан негіз топырақтарының сипаттамалары	
<i>Abdygaliyev A.E., Zhakulin A.S., Zhakulina A.A., Toimbaeva B.M.</i> Water saturated foundation soil Features	
<i>Абдығалиев А.Е., Жакулин А.С., Жакулина А.А., Тоимбаева Б.М.</i> Характеристики водонасыщенных грунтов основания	17
<i>Алдуңгарова А., Жусупбеков А., Абишева А.</i> Іргетас деформацияларының құрылыс құрылымдарының тұрақтылығына әсері	
<i>Aldungarova A., Zhussupbekov A., Abisheva A.</i> Influence of deformations of foundations on the stability of building structures	
<i>Алдуңгарова А., Жусупбеков А., Абишева А.</i> Влияние деформаций фундаментов на устойчивость строительных конструкций	25
<i>Ашкей Е., Жусупбеков А.Ж., Досмухамбетова Б.К.</i> Талдау тығыздағыш тор «ЭКСПО-2017» (Нұрсұлтан, Қазақстан) құрылыс алаңы жүктеме астындағы сынақ талдамасы	
<i>Ashkey E., Zhussupbekov A.Zh., Dosmukhambetova B.K.</i> Analysis of O-Cell Loading Piling Test at construction site of Expo 2017, Nur-Sultan, Kazakhstan	
<i>Ашкей Е., Жусупбеков А.Ж., Досмухамбетова Б.К.</i> Анализ испытания свай по результатам O-Cell метода на строительной площадке ЕХРО-2017, Нур-Султан, Казахстан	40
<i>Жакулин А.С., Жакулина А. А., Жаутикова С. А., Есентаев А. У.</i> Қазақстан Республикасының құрылыс нормаларында «Геотехника-7» Еурокодын бейімдеу	
<i>Zhakulin A.S., Zhakulina A.A., Zhautikova S.A., Yessentayev A.U.</i> Adaptation of Eurocode «Geotechnics-7» in the Building Norms of the Republic of Kazakhstan	
<i>Жакулин А.С., Жакулина А. А., Жаутикова С. А., Есентаев А. У.</i> Адаптация Еврокода «Геотехника-7» в строительных нормах Республики Казахстан	48
<i>Жусупбеков А., Шин Е.Ч., Шахмов Ж., Тлеуленова Г.</i> Топырақты топырағын мұздату және еріту кезінде модельдік қадаларды эксперименттік зерттеу	
<i>Zhussupbekov A., Shin E.Ch., Shakhmov Zh., Tleulenova G.</i> Experimental investigations of model pile in freezing and thawing of soil ground	
<i>Жусупбеков А., Шин Е.Ч., Шахмов Ж., Тлеуленова Г.</i> Экспериментальные исследования модельной сваи при промерзании и оттаивании грунтового грунта	56
<i>Ивасаки Я., Петухин А., Танырбергенава Г., Жусупбеков А.</i> Алматы метрополитені тұрғысынан Осакадағы жасырын ақауға және Кобе жер сілкінісінен болатын зақымға қарсы Метрополитен жүйесін Асейсмикалық жобалауға шолу	
<i>Iwasaki Y., Petukhin A., Tanyrbergenova G., Zhussupbekov A.</i> Overview of Aseismic Design of Subway System against Hidden Fault in Osaka and Damages by Kobe Earthquake in terms of Almaty Subway	
<i>Ивасаки Я., Петухин А., Танырбергенава Г., Жусупбеков А.</i> Обзор асейсмического проектирования системы метрополитена против скрытого разлома в Осаке и повреждений от землетрясения в Кобе с точки зрения Алматинского метрополитена	62

<i>Кадыралиева Г.А., Джакунбеков Б.Т.</i> Тау-кен жұмыстарының әсер ету аймақтарындағы құрылыстардың орнықтылығын бағалау ерекшеліктері	
<i>Kadyralieva G.A, Dzhaqunbekov B.T.</i> Assessment peculiarities of the constructions stability in the areas of affected by mining operations	
<i>Кадыралиева Г.А., Джакунбеков Б.Т.</i> Особенности оценки устойчивости сооружений в зонах воздействия горных работ	74
<i>Калякин В.Н.</i> Анизотропты топырақтарға арналған Пуассон коэффициенттеріне қатысты кейбір бақылаулар	
<i>Kaliakin V.N.</i> Some Observations Regarding Poisson's Ratios for Anisotropic Soils	
<i>Калякин В.Н.</i> Некоторые наблюдения относительно коэффициентов Пуассона для анизотропных грунтов	83
<i>Линг Хое И., Линг Генри</i> Супертайфун кезінде жауын-шашыннан туындаған беткейдің бұзылу мысалы	
<i>Ling Henry, Ling Hoi I.</i> A Case Study of Slope Failure Induced by Rainfall During Super-Typhoon	
<i>Линг Хое И., Линг Генри</i> Пример разрушения склона, вызванного осадками во время супертайфуна	101
<i>Ли Лиминг, Хунг Чи-Яо</i> Түйіршікті ағын мен шекаралық эрозияны центрифугалық модельдеу	
<i>Liming Li, Chi-Yao Hung</i> Centrifuge modelling on granular flow and boundary erosion	
<i>Лиминг Ли, Чи-Яо Хунг</i> Центрифужное моделирование зернистого потока и пограничной эрозии	110
<i>Нозаки Т.</i> Жол теміржол тіреу қабырғаларына қадаларды сығымдау әдісі	
<i>Nozaki T.</i> Press-in Piling Method for Road/ Railway Retaining Walls	
<i>Нозаки Т.</i> Способ прессования свай для дорожных железнодорожных подпорных стенок	120
<i>Сонг К.Р., Ченг А.Х-Д., Остаз А.Аль, Мантена Р.</i> «Катрина» дауылынан кейінгі жағдай салдарының экономикалық тиімді модернизация әдістеріне екпін беруі	
<i>Song C.R., Cheng A.H-D., Ostaz A.Al, Mantena R.</i> Lessons Learned from Hurricane Katrina – With Emphasis on Cost Effective Retrofitting Techniques	
<i>Сонг К.Р., Ченг А.Х-Д., Остаз А.Аль, Мантена Р.</i> Уроки, извлеченные из урагана «Катрина» – с акцентом на экономически эффективные методы модернизации	127
<i>Тельтаев Б.Б., Суппес Е.А.</i> «Алматы-Бишкек» автомобиль жолының жер төсеміндегі температура мен ылғалдылық	
<i>Teltayev B.B., Suppes E.A.</i> Temperature and moisture in subgrade of the highway «Almaty-Bishkek»	
<i>Тельтаев Б.Б., Суппес Е.А.</i> Температура и влажность в земляном полотне автомобильной дороги «Алматы-Бишкек»	134
<i>Түлебекова А.С., Жусупбеков А.Ж., Жанкина А.К.</i> ASTM және ГОСТ стандарттары бойынша қадаларды сынау әдістері	
<i>Tulebekova A.S., Zhussupbekov A.Zh, Zhankina A.K.</i> Methods of testing pile by ASTM and GOST Standards	
<i>Түлебекова А.С., Жусупбеков А.Ж., Жанкина А.К.</i> Методы испытаний свай по стандартам ASTM и ГОСТ	141
<i>Шакирова Н., Жусупбеков А., Алибекова Н., Морев И., Боргекова К.</i> Бұрғыланған қадалардың тұтастығын екі әдіспен тексеру: төмен деформация әдісі және көлденең ұңғымалық акустикалық каротаж-қолдану тәжірибесі	150
<i>Shakirova N., Zhussupbekov A., Alibekova N., Morev I., Borgekova K.</i> Checking Integrity of Bored Piles Using Two Methods: Low Strain Method and Cross-Hole Sonic Logging - Experience of Application	150
<i>Шакирова Н., Жусупбеков А., Алибекова Н., Морев И., Боргекова К.</i> Проверка целостности буронабивных свай двумя методами: методом низких деформаций и поперечным скважинным акустическим каротажем – опыт применения	150

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Assessment peculiarities of the constructions stability in the areas of affected by mining operations

Abstract. *In connection with the migration flow and the growth of cities in recent years, there has been an active construction of high-rise buildings in the Kyrgyz Republic. The huge and chaotic development of the capital of the country of Bishkek has become a big problem for both city dwellers and environmentalists. In addition to the climatic and seismic conditions of the region, which complicate the stability of an apartment house, construction is also carried out near mining operations that take place on the outskirts of the city. And in connection with the expansion of the city's areas, the growth of apartment houses has started more and more near such sites, which causes special issues and concern of the population and buyers of apartments of such houses. Concerning to this, the purpose of our study is to assess peculiarities of the stability of the foundation of structures in affecting zones of mining operation. Under these circumstances, it is first necessary to calculate the stability of the pit for the calculation of which the Bishop-Jambu method was used.*

Key words: *stability, slope, mining, methods.*

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Reasons for scientific research. It is known that in order to be stable of the construction its foundation should be deepened to a certain depth, the strength of any constructed construction is primarily from the base and foundation. [1] The design of the foundations of buildings and structures depends on a large number of factors, the main of which are: the geological and hydrogeological structure of the soil; climatic conditions of the construction area; construction of the building and foundation to be constructed; the nature of the loads acting on the foundation soil, etc. In terms of Kyrgyzstan, the above-indicated factors include still high seismic hazard of the region. Concerning the migration flow to the capital of the country Bishkek in recent years, there has been an active construction of high-rise buildings. The huge and chaotic development of Bishkek has become a big problem.

Background. Bishkek is the capital of Kyrgyzstan with a population of about 1 million people, is located in the Chui Valley at the northern foot of the Kyrgyz range, which is part of the large Tien Shan mountain chain, at an altitude of 700-900 meters above sea level. (Figure1) About 90 nations live in the city. The interethnic language of communication is Russian.

The construction of the city can be divided into several stages, the first of which was connected with the ideas of constructivism that came in the 1920s.

By the next stage can be attributed to the end of 30 years, when professional architects arrived in Bishkek and construction of new buildings started and new projects appeared.

The third stage of city development is the post-war years, when urban development was rapidly developing under a series of standard projects with the introduction of prefabricated structures. [2]



Figure 1. General view of the city Bishkek

To date, the city's territory is 160 km² and due to the location of the city near two faults of Chon-Kurchak and Ysyk-Ata, which are located within the North Tien Shan zone any apartment houses were not built in the city. These two seismic faults are dangerous for two reasons: firstly, the zone of such faults, as a rule, is represented by fragmented products of tectogenesis, having dangerous seismic properties; secondly, with strong earthquakes in such zones and in the sediments covering them, the manifestation of residual seismic deformations that dramatically enhances the seismic effect on the earth's surface is possible. [3] And therefore, residential apartment houses mostly have a height of 6 or 9 floors. But with the advent of new projects in compliance with international standards, the construction of apartment buildings began in recent years and in Bishkek with the example of Japan, Almaty and other countries with a high seismic zone. In 2015, the highest house in the city was built on 25 floors.

In the last 7-8 years, according to the development of the capital for 2017-2020, the city is expanding very rapidly. Most apartment houses are built on 9-12 floors. But the expansion of the city is complicated by the fact that in the outskirts there are open pits of mining construction materials in the form of sand, gravel, gravel and pebbles. The largest enterprise for the production of nonmetallic materials is the open pit «Sand-Gravel», located on the south-eastern outskirts of the city. (Figure 2)



Figure 2. Open pit of non-metallic materials «Sand-Gravel»

The open pit began to be developed in 1968 and functions to this day. The total area of the open pit is 16 hectares, the work is conducted year-round and on average 16-17 tons of dust are emitted into

the atmosphere every year. But due to the large flow of residents from the regions to the country's capital, the city is being built and expanding despite, but the obvious danger of living in houses is being built with great risk near the huge excavation pits left after the development of deposits of construction materials. (Figure 3)



Figure 3. Buildings of apartment houses near excavations

Because of these problems, we conducted studies on the features of assessing the stability of the sides of the pit taking into account the building that is under construction.

It is known that the excavation of significant volumes of rocks leads to a disruption of the existing equilibrium in the rock mass, which in turn causes deformation of rocks in the slopes and outcrops of the open pit. In those cases, when the values of deformations reach or exceed the maximum permissible, the structural bonds in the rocks are destroyed, the development of displacements toward the worked-out space and the deformation of the slopes. For prevention, which previously predicted and calculated the stability of the sides of the open pit. Under the forecast of stability of pit edge to understand scientifically and experimentally proved behavior of side massif and dumps over time or in a modified natural and man-made geomechanical conditions.

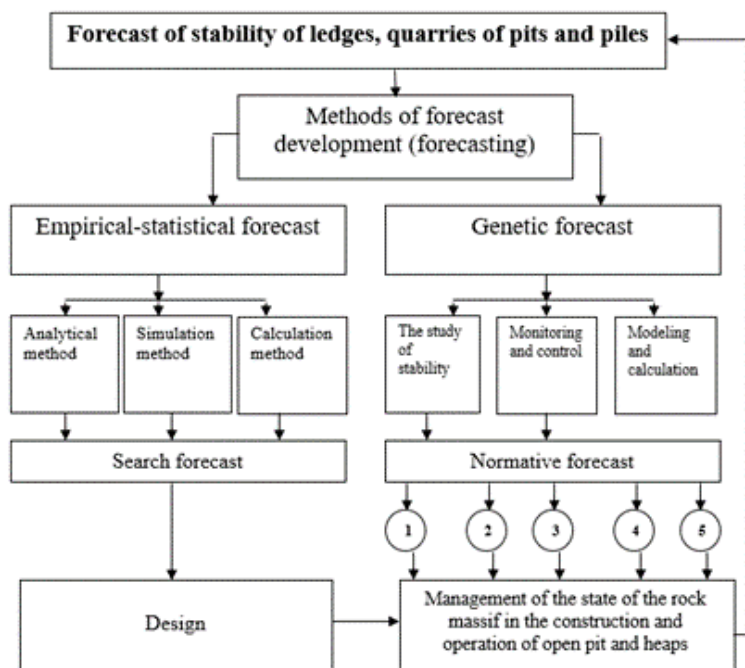


Figure 4 Scheme of a complex system for predicting the stability of slopes
 1-operative; 2-short-term; 3-medium-term; 4-term; 5-year-long

Survey on aerial photographs for changing the parameters of the quarry and the adjacent territory in the periods from 2005-2016. drawings are taken in Google Earth Pro. Early aerial photographs are not available in the archives of Google Earth Pro and do not provide the possibility of visual analysis until 2005. (Figure 7)

Calculating the stability of the edges of pit or slopes is one of the most important engineering and geological tasks. To solve it, numerous methods have been developed within the framework of the theory of limiting equilibrium. [4] As a mechanism for loss of stability, the sliding mechanism of the sliding massif is taken with respect to the fixed part of the slope. The boundary of a section is called the sliding surface. Of the known methods for calculating the stability of slopes, the most widely known and well-known method of a circular-cylindrical slip surface was used, by the Bishop method in combination with the Jambu method, based on the limiting equilibrium of a device array over potential slip surfaces.

Calculation and assessment of the stability of the edges of the pit were carried out on the requirements of IRM 218.2.006-2010 [5], and the stability criterion is the safety margin factor, which should be greater than the normative one, i.e. $K_s > 1.3$.



Figure 7. Changes in the parameters of the pit from 2005 to 2016.

Materials and methods. The coefficient of stability is characterized by the ratio of the shearing and retaining moments of forces, while it is assumed that the landslide array is rigidly displaced along the slip surface. The main parameters provided for calculations are the angle of internal friction, clutch, rock density and geometric parameters. The calculation scheme is shown in Fig. 8.

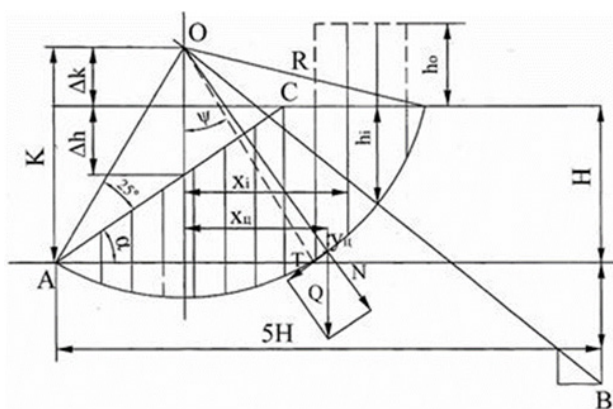


Figure 8. Calculation scheme for determining the safety factor of stability.

The edge of the pit is divided into blocks and within each block the restraining and shearing forces and values of the coefficient of stability are calculated, according to the following formula:

$$K_y = \frac{P \cos \alpha \operatorname{tg} \varphi' + C' S}{P \sin \alpha}$$

where, P - is the mass of the entire prism of a possible collapse;

S - is the area of the potential collapse surface; C', and φ' - is the calculated clutch and the calculated angle of internal friction along the potential slip surface; α - is the angle of inclination of the weakening surface, over which collapse is possible.

The main program for calculating stability is GEO5. The program provides for entering the boundaries of the contour of the rock object (geometric parameters), strength and density properties of rocks, overloading if there is a structure, anchoring, groundwater level, seismicity of the area, calculation of the stability of geotechnical structures and output of results. In calculating the stability of the edges of the pit, in addition to the Bishop-Jambu method, other methods are also envisaged, which include the Peterson method, the Spencer method, and the Shahunyants method.

Calculations were made for several sections taking into account the mound of construction debris on the quarry and without taking into account the mound. Also in the calculations, the stability of the slope was considered taking into account the seismicity of the region and without it. The seismicity of the area was taken 6-8 points. Below are the results of calculating the stability of the pit side along the section 1-1 with allowance for the embankment, but without considering the seismicity of the area. (Figure 9)

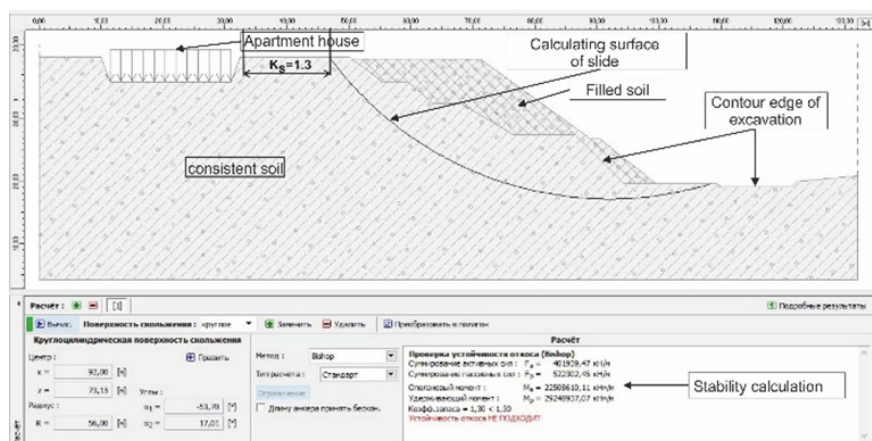


Figure 9. Calculation of the stability of the pit edge along the cross section 1-1 without taking into account the seismicity of the area.

In this section, the calculations of the coefficient of stability are $K_y = 1.3$ and over the indicated slip surface, the slope is in the limiting state at the horizon of 47 m. Calculations at a mark beyond 47m in the direction of the quarry to 68m showed that the slope is not stable and $K_s < 1.3$. That is, the edge of the pit along the circular cylindrical sliding surface in the range from the foundation of the house to the beginning of the slip line along the horizontal surface of the Earth is 34m-46m in a stable state ($K_u > 1.3$), and starts from the slip line towards the pit in an unstable state. Figure 10 shows the results of calculations taking into account the seismicity of the area.

On the basis of the obtained results for section 1-1, it can be concluded that when taking into account the seismicity of the area, the slip surface line at horizontal elevations of 35m-37m-the slope is in the limiting state, starting from the 37-38m mark, the slope turns into an unstable state. In the same way, calculations were carried out on 5 sections, according to which it was established that the side of the pit where construction of the house is being made is stable, even taking into account the seismicity of the area.

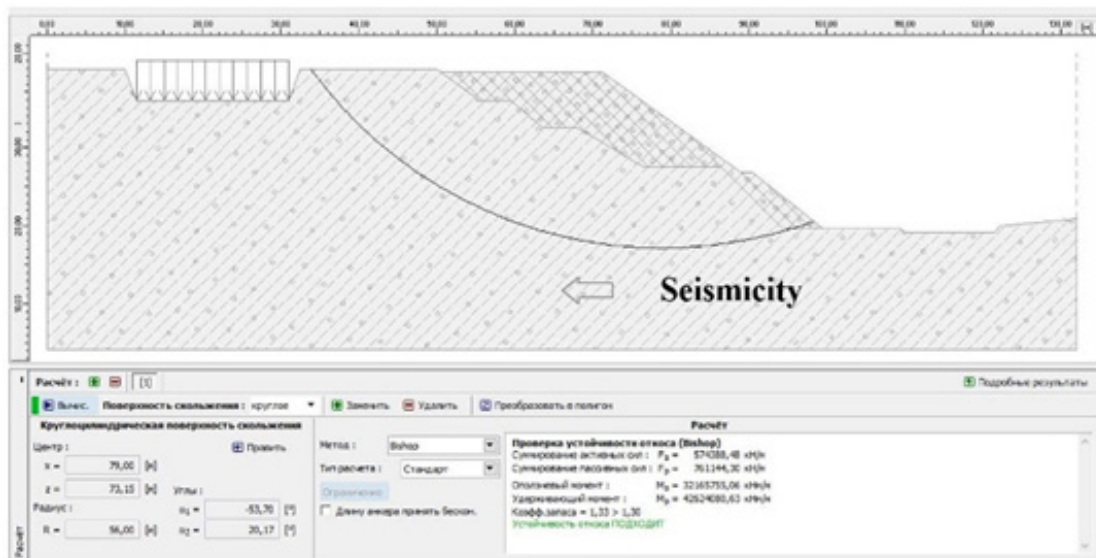


Figure 10. Calculation of the stability of the pit edge taking into account the seismicity of the area

On the average, the stability coefficient of the bead is $K_s=2.0$. And in calculations where the seismicity of the area was not taken into account, the stability coefficient is equal to $K_s=3.12$. The results were also confirmed by calculations using the methods of Bishop, Peterson, Spencer, and Shahunyan.

To assess the stability of the base of the building, calculations were also made on the PLAXIS program, where, as a result, it was revealed that the foundation of a residential unfinished house has a drawdown in the center of the base at 35.51mm.

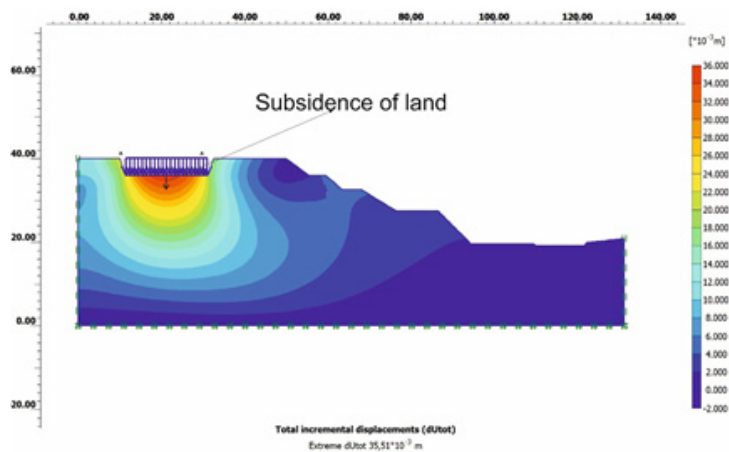


Figure 11. Result of calculations of stability of the foundation of a building

The cause of deformation displacement of the base of the building is not a detailed study of the properties of the soil of the massif. In this regard, strengthening the base of the building with additional measures.

Conclusions. On the basis of the calculations of stability of assessment, and its effect on the base near the residential building under construction and analysis of the results obtained show that:

1. the pit edge is in the limit stable state at the «foundation-side» distance both with and without seismicity of the area;
2. if a part of the pit edge without a mound is in an unstable state, then the stability factor with the building debris is in the range $K_s=1.3-2.6$. Such a change is characterized by the positive influence of the bulk soil on the stability of the pit edge.

3. the spent pit does not affect deformation or any disturbances on the basis of the house;
4. in order to bring these sections into a guaranteed stable state, it is necessary to carry out a number of measures to strengthen the quarry side.

Proposed measures for the safe construction of an apartment house, in connection with the obtained results and the conclusions:

1. fill the proper side of the pit with construction waste, sprinkle 1.20m of crushed soil on top and compact to a density of 2.00t/m³;
2. do not perform any construction operations at a distance «foundation-side»;
3. to do additional strengthening operations of the foundation of the building and to ensure drainage of water from precipitation.

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Тау-кен жұмыстарының әсер ету аймақтарындағы құрылыстардың орнықтылығын бағалау ерекшеліктері

Аңдатпа. Көші-қон ағынына және қалалардың өсуіне байланысты соңғы жылдары Кыргыз Республикасында көп қабатты ғимараттардың белсенді құрылысы жүріп жатыр. Ел астанасы Бішкектің орасан зор және ретсіз салынуы қала тұрғындары үшін де, экологтар үшін де үлкен проблемаға айналды. Көп пәтерлі үйлердің тұрақтылығын қиындататын аймақтың климаттық және сейсмикалық жағдайларынан басқа, құрылыс қала шетінде өтетін тау-кен жұмыстарының жанында да жүргізілуде. Қала алаңдарының кеңеюіне байланысты мұндай нысандардың жанында көп пәтерлі үйлердің көбеюі жиілей түскен,

бұл тұрғындар мен осындай үйлердің пәтерлерін сатып алушылардың ерекше мәселелері мен алаңдаушылығын тудырады.

Осыған байланысты біздің зерттеуіміздің мақсаты тау-кен жұмыстарының әсер ету аймақтарындағы құрылыстар іргетастарының орнықтылық ерекшеліктерін бағалау болып табылады. Бұл жағдайда, алдымен, есептеу үшін Бишоп-Джамбу әдісі қолданылған шұңқырдың тұрақтылығын есептеу керек.

Түйін сөздер: тұрақтылық, көлбеу, тау-кен жұмыстары, әдістер.

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Особенности оценки устойчивости сооружений в зонах воздействия горных работ

Аннотация. В связи с миграционным потоком и ростом городов в последние годы в Кыргызской Республике идет активное строительство высотных зданий. Огромная и хаотичная застройка столицы страны Бишкека стала большой проблемой как для горожан, так и для экологов. Помимо климатических и сейсмических условий региона, которые осложняют устойчивость многоквартирных домов, строительство ведется также вблизи горных работ, которые проходят на окраинах города. А в связи с расширением площадей города все чаще вблизи таких объектов начинается рост многоквартирных домов, что вызывает особые вопросы и озабоченность населения и покупателей квартир таких домов.

В связи с этим целью нашего исследования является оценка особенностей устойчивости фундаментов сооружений в зонах влияния горных работ. В этих условиях сначала необходимо рассчитать устойчивость котлована, для расчета которой использовался метод Бишоп-Джамбу.

Ключевые слова: устойчивость, склон, горные работы, методы.

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