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Geo-Institute (American Society of Civil Engineers), 1801 Alexander Bell Drive Reston, VA 20191, USA
Kazakhstan Geotechnical Society, Temirtau, Av. Respubliki 5-9, Karaganda city, Kazakhstan, 10140

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

G. Kadyralieva, Institute of Geomechanics and Development of subsoil of the National Academy of Sciences of the Kyrgyz Republic, Bishkek, Kyrgyzstan, gulzat_7@list.ru
B. Dzhakupbekov, Institute of Geomechanics and Development of subsoil of the National Academy of Sciences of the Kyrgyz Republic, Bishkek, Kyrgyzstan, belekjak@gmail.com
S. Kuvakov, Institute of Geomechanics and Development of subsoil of the National Academy of Sciences of the Kyrgyz Republic, Bishkek, Kyrgyzstan, stalbekuvakov@gmail.com

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 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 assessing 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.

Introduction

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 term of Kyrgyzstan, the above indicated factors include still high seismic hazard of the region. Concerning to 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. (fig.1) 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.

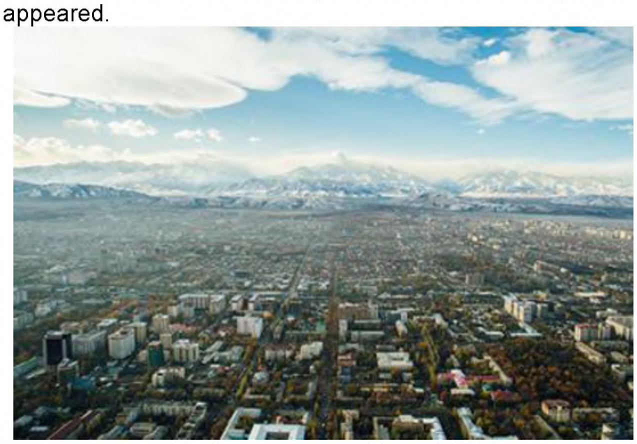

Figure 1. General view of the city Bishkek

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]
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. Mostly 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-Grave», located on the south-eastern outskirts of the city. (fig.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. (Fig.3) Because of with 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 3. Buildings of apartment houses near excavations

The forecast is carried out on the basis of the field observations of the shifts of the edges of the pit, the estimation and calculation of the margin factor of the open pit edges are made. The forecast plays an important role in managing the state of the rock massif, as it is based on technological solutions that ensure the safety of the geotechnical object during its operation.

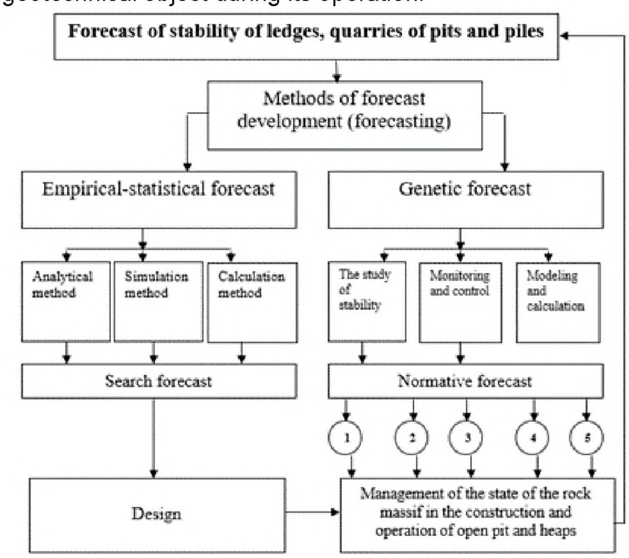

Figure 4 Scheme of a complex system for predicting the stability of slopes
1-operative; 2-short-term; 3-medium-term; 4-term; 5-year-long

Experimental Investigation

The object of our research was the open pit of constructions materials, located outside the city, the territory of which is equipped with the construction of apartment buildings. The construction of the 9- apartment building is carried out at a distance of 19m from the contour of the side of the pit, (Fig.5) and carries a potential danger to the stability of the foundation of the building. The aim of the research work was to calculate the stability of the pit edges taking into account the building and to reveal the influence of deformation displacements on the foundation of the building.

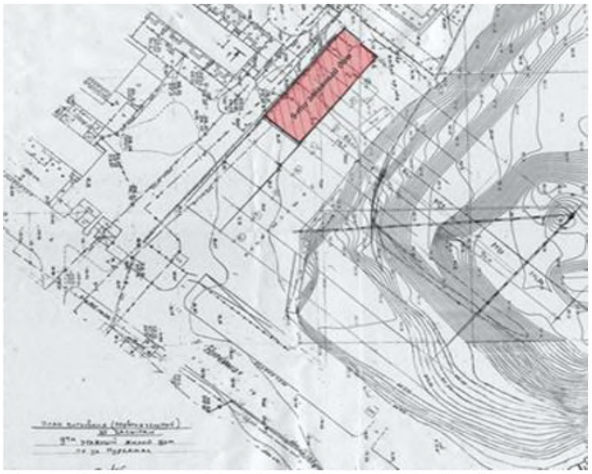

Figure 5. Topographic plan of the spent pit with indication of a 9-appartment building

Based on the results of the visual survey of the territory, a crack with an opening of 6 cm from the edge of the pit at a distance of 5-6 m was detected and surface subsidence was observed in this zone. Currently, the backfilling of the pit is carried out with a construction trash: gravel, crushed stone, fragments of concrete, asbestos pipes and asphalt. (Fig. 6)

Figure 6. The topographic plan shows the house under construction and the crack identified.

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. (Fig. 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.

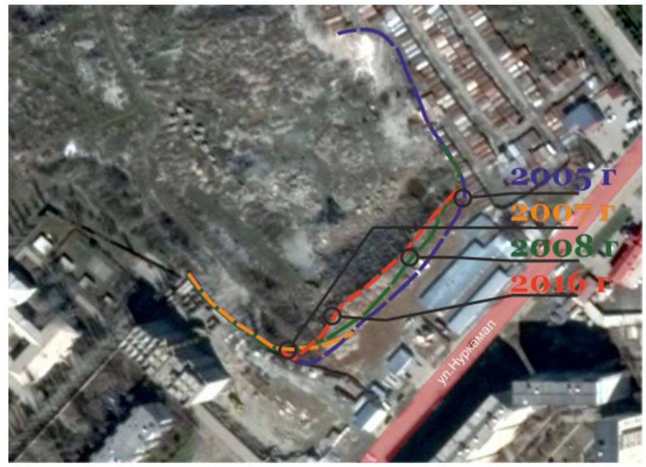

Figure 7. Changes in the parameters of the pit from 2005 to 2016.

Calculation and assessment of the stability of the edges of the pit was 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. Ks> 1.3.

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.

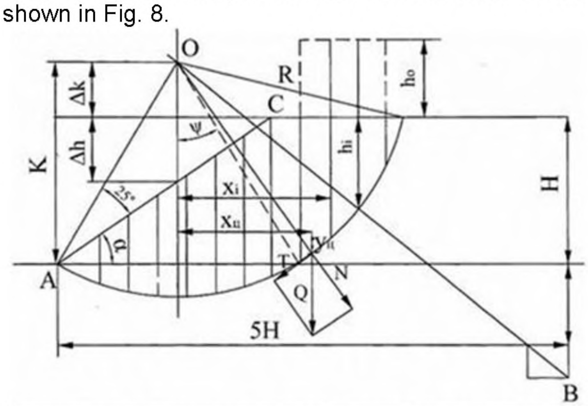

Figure 8. Calculation scheme for determining the safety factor of stability.

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:

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

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. (Fig. 9)

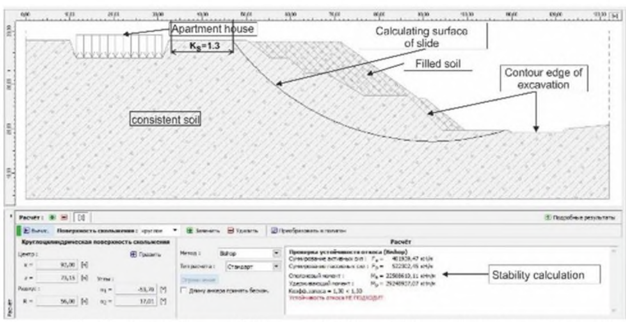

Figure 9. Calculation of the stability of the pit edge along the cross section 1-1 without taking into account the seismicity of the area.

In this section, the calculations of the coefficient of stability are Ky = 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 Ks <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 (Ku> 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.

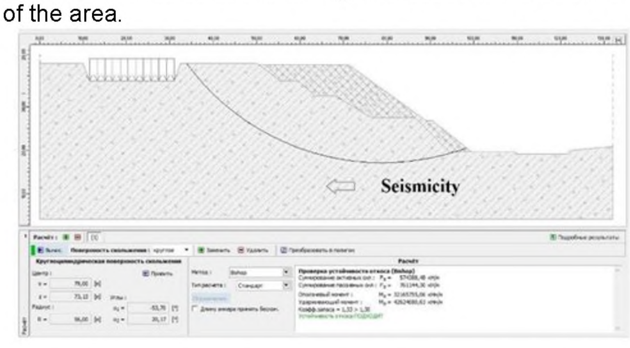

Figure 10. Calculation of the stability of the pit edge taking into account the seismicity of the area

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

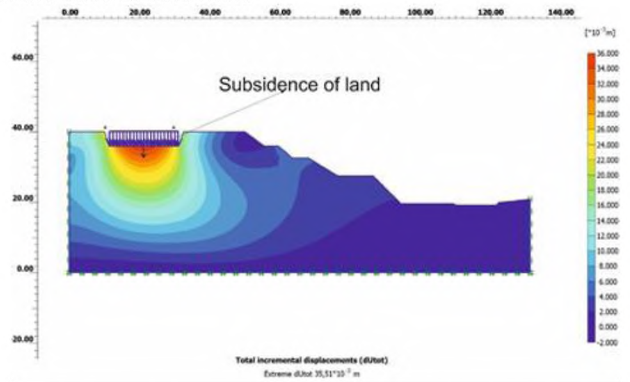

Figure 11. Result of calculations of stability of the foundation of a building

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, strengthen the base of the building with additional measures.
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 Ks=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/m^3;
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.

References

Denisov O.G. Grounds and foundations of industrial and civil buildings (with elements of soil science and soil mechanics). Publishing house "Higher School" Moskov 1968

IRM 218.2.006-2010 Recommendations for calculating the stability of landslide slopes and determining landslide pressures on engineering structures of highways / Supervisor - Matsiy SI, doctor of technical sciences. Sciences, Professor. The document was developed by candidates of technical sciences Bezuglova EV, Derevets FN. and Eshchenko O.Yu. // orders from 30.03.2011 N 249-r.

Ivasenko L. A Brief History of the Origin of Bishkek. AllKyrgyzstan (May 30, 2008). Verified on October 12, 2012. Archived on October 16, 2012

Juan Y.H. Stability of earthen slopes. Moscow: Stroiizdat, 1988.

Khramova N. History of the formation of Soviet architecture in the city of Bishkek. The project "Soviet architecture". Verified on October 12, 2012. Archived on October 16, 2012.