

STUDY OF THE RAVINE-GULLY SYSTEM OF THE CITY OF DNIPRO WITH THE AIM OF RETURNING THEIR TERRITORIES TO THE URBAN INFRASTRUCTURE

¹Zmievskya K.O., ²Zmievskiy A.S.

¹*Institute of Geotechnical Mechanics named by N. Poliakov of National Academy of Sciences of Ukraine,* ²*LLC "Epiroc Ukraine"*

ДОСЛІДЖЕННЯ ЯРОВО-БАЛКОВОЇ СИСТЕМИ МІСТА ДНІПРО З МЕТОЮ ПОВЕРНЕННЯ ЇХ ТЕРИТОРІЙ В МІСЬКУ ІНФРАСТРУКТУРУ

¹Змієвська К.О., ²Змієвський А.С.

¹*Інститут геотехнічної механіки ім. М.С. Полякова НАН України,* ²*ТОВ «Епірок Україна»*

ИЗУЧЕНИЕ ОБРАЖНО-БАЛОЧНОЙ СИСТЕМЫ ГОРОДА ДНЕПР С ЦЕЛЮ ВОЗВРАЩЕНИЯ ИХ ТЕРРИТОРИЙ В ГОРОДСКУЮ ИНФРАСТРУКТУРУ

¹Змиевская К.О., ²Змиевский А.С.

¹*Інститут геотехнічної механіки ім. Н.С. Полякова НАН України,* ²*ООО «Эпирок Украина»*

Annotation. Purpose. It consists in studying the ravine-gully system of the city of Dnipro, determining the degree of development of landslide hazardous phenomena and identifying the possibility of returning the territories of ravines and gullies to maintenance. Methods. The study of the ravine-gully system of the city of Dnipro was carried out by reconnaissance studies, during which a description of the sides of the gully and ravines was carried out, examples, the degree of their development, the presence of a drainage system, and the prospects of their use were given. In accessible areas of ravines and gullies, in order to assess the landslide hazard of the slope, an operative geophysical express method was used to observe the natural impulse electromagnetic field of the Earth with an instrument such as a radio wave indicator of the stress-strain state of rocks. Results. The article provides an analysis of the state of individual fragments of a ravine-gully system in the right-bank part of the city of Dnipro and its impact on the urban infrastructure. Examples of the successful use and construction of ravines with buildings and structures are considered. According to the results of the survey by the method of the natural impulse electromagnetic field of the Earth, a map-scheme of the flux density of the natural impulse electromagnetic field of the Earth was constructed in the area adjacent to the Monument of Glory, showing the presence of a previously covered ravine. The deformation processes that are observed on the eastern side of the Monastyrskya gully are analyzed. Methods for strengthening landslide-prone slopes are considered. Scientific novelty. For the first time, using the method of observing the natural impulse electromagnetic field of the Earth in the areas of the Glory Monument and Monastyrskya gully, maps-scheme of the density of the natural impulse electromagnetic field of the Earth were constructed, which made it possible to identify areas prone to deformations of the soil mass and further subsidence processes. Practical significance. Based on the studies, it is possible to recommend the use of the method of observing the natural impulse electromagnetic field of the Earth, which allows to identify slopes and lands prone to landslides, which can later be used in urban infrastructure at low loads on the soil mass.

Keywords: natural impulse electromagnetic field of the Earth, ravine-gully system, the right-bank part of the city of Dnipro, Monastery gully, monument of Glory.

Introduction. Currently, in the conditions of rapid urbanization of the territories of the city of Dnipro, various negative geo-ecological processes are actively manifested, which are progressing and negatively affecting the normal functioning of the city's systems. One of the most dangerous geo-ecological problems for an urban area are landslide processes and underflooding. The main reasons that stimulate the activation of these processes are:

- the influence of the fault-block system of the Serednoprudniprovskiy megablock;

- groundwater level rise;
- poor drainage areas;
- pressure of residential, industrial and transport systems and structures on the soil massif;
- construction residential and industrial buildings and structures without taking into account the slopes of geomorphological structures (terraces of the Dnipro river, gullies) and, accordingly, prevent the natural flow of surface and groundwater;
- gusts of water-bearing communications, etc.

All these negative factors contribute to the development of landslide processes, as well as the active growth of the ravine-gully system, which leads to the removal from the economic turnover of valuable land for the city, mainly located in the central regions.

Within the limits of the right-bank part of the city of Dnipro, there are about 15 gullies and more than 20 ravines, which are constantly developing. Their average depth is 30-40 m, they occupy about 5 thousand hectares, which is more than 25 % of the territory under consideration. As a rule, gullies and ravines, especially the central part of the city, are intensively built up with one-storey, multi-storey and civil structures.

Gullies and ravines are natural drainage systems for both sediment drainage and leaks from water-carrying communications. Spontaneous landfills and uncontrolled low-rise buildings retain water, which causes numerous minor ground collapses and landslides. Among the most landslide-prone areas are the slopes of the Tunelna, Dovha, Yevpatoriiska, Diivska, Aptekarska, Zustrichna gullies. Most of the landslides were caused by human activities and a small part due to natural factors.

In this connection, the aim of the work is to study the ravine-gully system of the city, determine the degree of development of landslide-prone phenomena and identify the possibility of returning the territories of ravines and gullies into exploitation.

Methods. The study of the ravine-gully system of the city of Dnipro was carried out by means of reconnaissance studies, during which a description of the sides of the gullies and ravines was made, examples were given - the degree of their development, the presence of a drainage system, the prospects of their use.

In the accessible parts of ravines and gullies, the operational geophysical express-method for observing the natural impulse electromagnetic field of the Earth (NIEMFE) was used to assess the landslide risk of the slope with a radio-wave indicator of a stress-strain state of rocks (RWISSS AXI 2.026.001) [1]. The observation data of the NIEMFE were processed using a personal computer, then they were used to construct a map-scheme of the density of the NIEMFE flow. Deformation processes associated with tectonic disturbances were distinguished using the previously developed method [2].

Results and discussion. It is known that the ravines and gullies are laid on the deep faults. For example, sections of river valleys and a gully system, which are straightforward, are located most often in agreement with the strike of one of the fracture systems.

The following fault systems are developed on the territory of the right-bank part of the city of Dnipro, which is a fragment of the Srednepridneprovsky megablock (Fig. 1): 0° - 360° , 12° , 17° and 290° , 25° , 30° and 300° , 35° and 305° , 40° - 45° and 310 - 315° , 50° and 320° , 85° - 90° (270°), 330° - 335° , 340° , 350° [3].



Figure 1 - Fragment of a tectonic map of the Srednepridneprovskyi megablock of the Ukrainian shield Scale 1:1 000 000

Examples of the use of a ravine-gully system in the central part of the city are given.

A fragment of Yavornytskoho Avenue from Haharina Avenue and up to the Glory Monument is a ravine which filled in the 1960's. Its thalweg depth reached 30 m. The length was about 600 m. Its negative impact is seen on the boulevard, in the area of the Glory Monument in the form of cracks on the parapet, asphalt, sliding steps in the direction of the thalweg of the ravine, destruction of the retaining wall, the development of subsidence of the base of the monument (Fig. 2 a, b, c).

To assess the deformation processes occurring in the area of the Glory Monument, observations were made of the NIEMFE on the site from Haharina Avenue to the railway line (Prospektna Station). The location of the observation profiles is shown in Figure 3.

Observations of NIEMFE were carried out in accordance with the developed and protected patent. [4], on 5 profiles which attached to the reference coordinate points.

Flow density is measured in c.u. (conditional units – number of impulses per unit time). Observations were made at 55 points. The distance between the observation points was 10 m. According to the observations, map-scheme of the NIEMFE flux was constructed (Fig. 4).

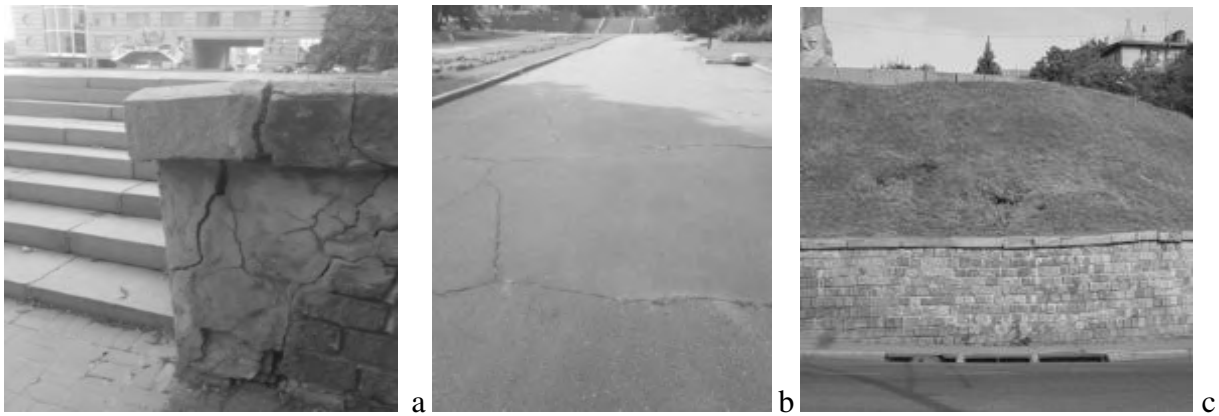


Figure 2 - Traces of parapet deformations in the area of the Glory Monument

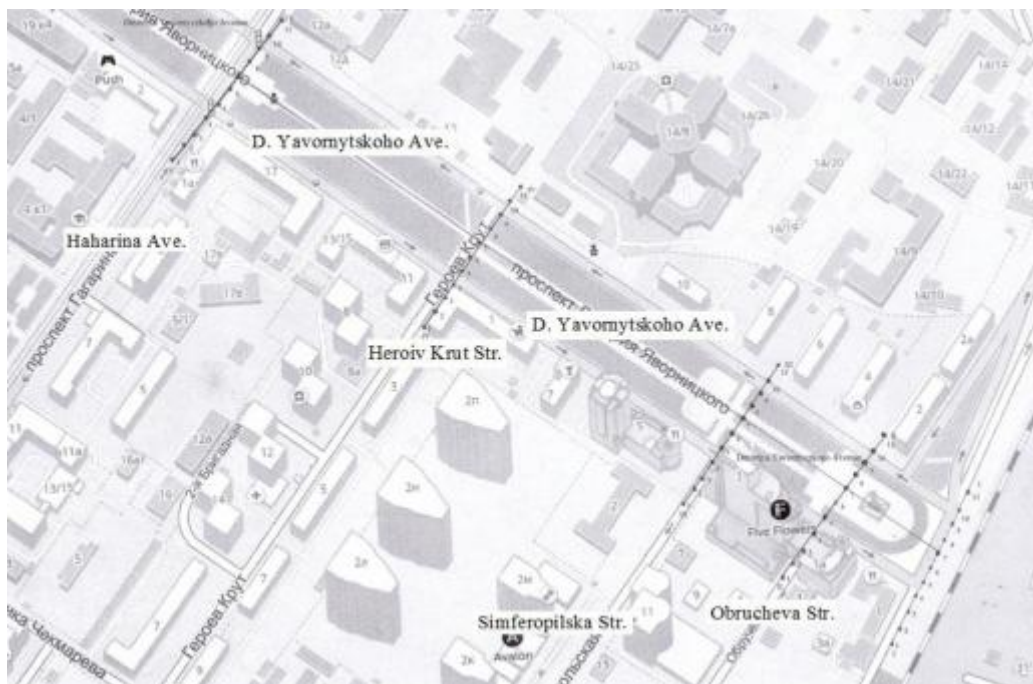
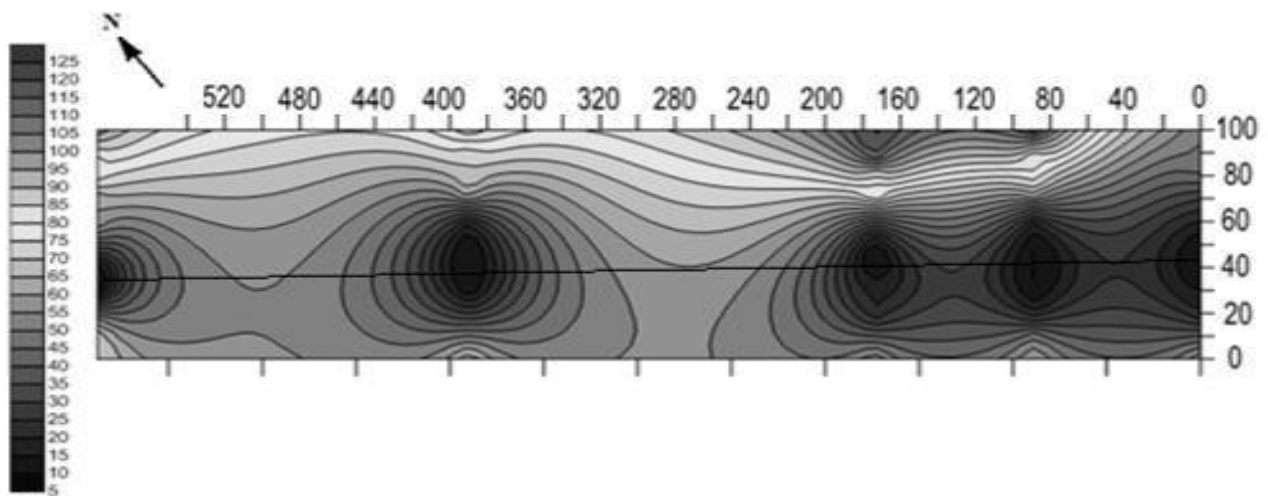


Figure 3 – Position of points and observation profiles of NIEMFE



☒ - isolines of flux density of NIEMFE, c.u.; ☒ - axis of the selected ravine structure

Figure 4 - Map-scheme of NIEMFE flux density site in the area of the monument of Glory

The flux density of NIEMFE at the study site varies from 1 to 125 c.u. When considering the resulting map-scheme, the attention is drawn to the clearly expressed linearity of the zone of minimum values (less than 35 cu), the axis of which has a strike azimuth of 310–315°. This direction is one of the main azimuths of the development of faults within the Srednepridneprovsky megablock. Attention is drawn to the zones of minimum values of NIEMFE, which coincide with the zones of the deformations described above. The presence of a sewer, located at the intersection of Heroiv Krut Str. and Yavornytskoho Ave. (profile IV) is reflected by a zone of low values of the density of the stream of NIEMFE - less than 35 c.u. (picket 380 along the X axis), is shown in Figure 4. Within the zones of low values of the NIEMFE flux density, intense destruction of the asphalt pavement, parapets, retaining walls, tiled pavements of the monument, sliding of steps and formation of saucers of subsidence of the Glory monument base are observed (Fig. 2 a, b, c).

Examples of the successful experience of using ravines in the urban infrastructure can be the following: a ravine, on the boards of which there are two blocks of the “Rassvet” Hotel, along the thalweg of which the passage to I. Akinfiieva (Fuchika) Str. is laid. Its dimensions are: thalweg length about 260 m, width about 15-17 m. The strike azimuth is about 85-90° (Fig. 5).

In its immediate vicinity is a beam passing through the 6th Strilkovoi Dyvizii str., on the bottom of which the stadium of the sports society “Slavutych” is equipped (Fig. 6 a, b). Its dimensions are: thalweg length about 260 m, width about 115 m. The strike azimuth is about 40-45°.



Figure 5 - An example of successful construction of a ravine on I. Akinfiieva street

One of the most built-up and problematic gullies in the city is Monastyrska (Rybalska). The length of the beam on the thalweg, taking into account the lightened part about 500 m. Gullies width about 385 m. Depth to thalweg about 40-60 m. The strike azimuth is 15-20°. A drain water collector with a diameter of about 1200 mm is laid along the bottom of the gully. Also there are numerous outlets of groundwater on the surface, forming waterways, sometimes swamped. Along the northeastern side of the gully are located Nakhimova str. and Havrylenka str., as well as buildings related

to the O. Polia ave., schools, garages, stone fences. The buildings of this side of the gully have a high number of floors 5-14 floors. On the Havrylenka str., Nakhimova str., and O. Polia Ave. laid the rainfall system. On the north-west side of the gully are located Kholodnoyarska str, Listovyi lane, “Meteor” stadium, garages. Buildings, mainly low-rise. The most pronounced deformations appear on the buildings of the north-east side of the gully: Havrylenka str., 10 (Fig. 7 a), O. Polia Ave., 92 A (Fig. 7 b) and Nakhimova str., 90 (Fig. 7 c), which are currently decommissioned.

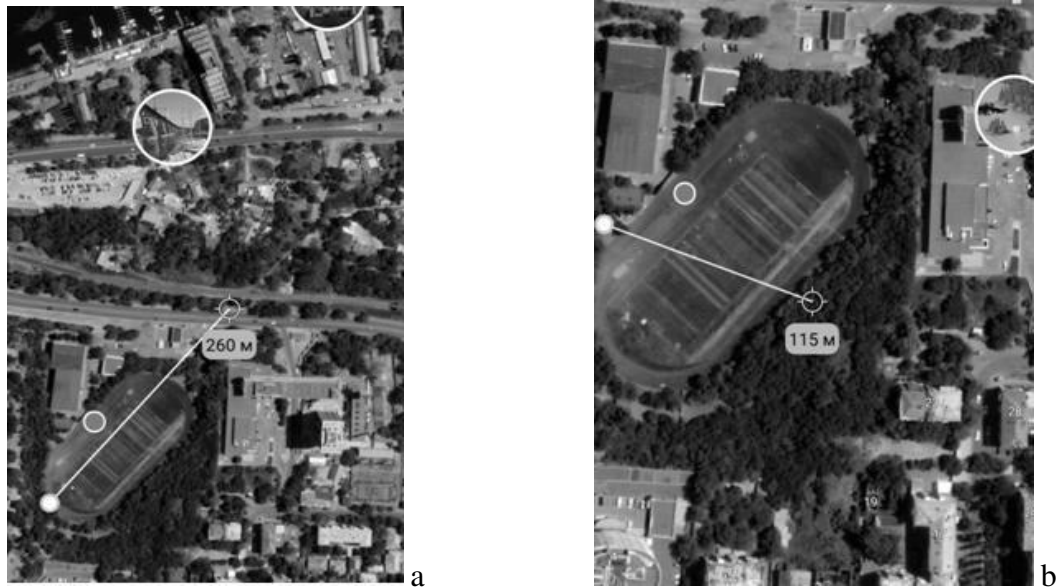


Figure 6 - Gully bottom construction along the 6th Strilkovoi Divizii str. with sports facilities of the “Slavutych” sports complex



Figure 7 - Deformations of buildings along the eastern side of the Monastirskyi gully



Figure 7 c - Deformations of buildings along the eastern side of the Monastirskyi gully

In 1996 and 2004 on the eastern side of the gully, observations of the NIEMFE were carried out [5].

According to the results of observations, zoning of the territory was carried out with the purpose of identifying tectonic zones along which landslide stages are formed. The slope profile has been used to plot graphs of the NIEMFE flux density, is shown in Figure 8.

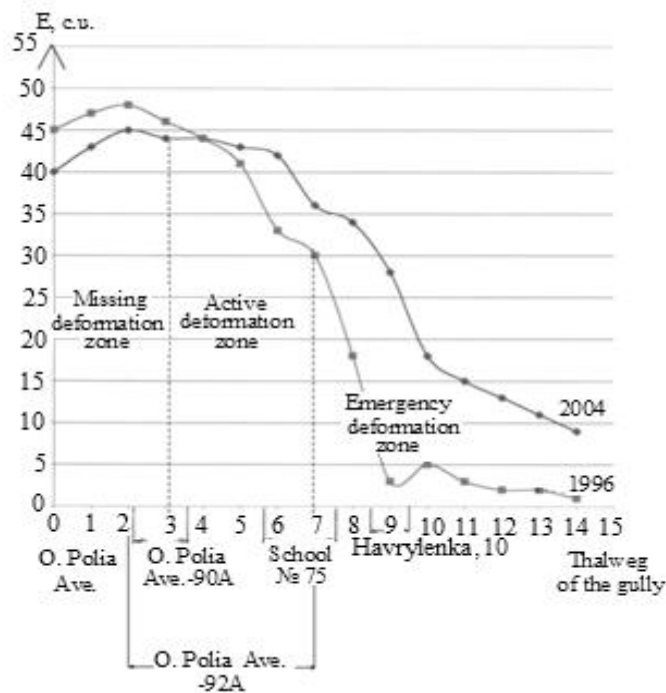


Figure 8 - Observation data of NIEMFE profile on the Havrylenka str. from O. Polia Ave. to thalweg Monastirskyi gully in 1996 and 2004 [5]

On the graphs can be identified zones of development of deformation processes:

- the zone of no deformations according to the observations of NIEMFE in 1996 - according to the field level of 45 c.u., according to the observations in 2004: 40-45 c.u.;

- zones of active deformations - according to the field level in 1996: 45-30 c.u. on the field level in 2004: 44-35 c.u.;

- zone of emergency deformations - according to the level of the field in 1996: 30-3 c.u.; by the level of 2004: 35-10 c.u.;

According to the observation of the NIEMFE, there is a discharge area - in the area of school number 75. Below the discharge area, there is a gradual increase in stresses, in the area of the building on Havrylenka str., 10 (Fig. 8).

The given examples of both the successful use of ravines and gullies, as well as the consequences of their destructive features, make the task of strengthening landslide-prone slopes for their further use relevant. One option is the methods developed by Epiroc, which is represented by LLC "Epiroc Ukraine".

The developed method allows to carry out drilling and sampling in difficult engineering and geological conditions and to create reinforcing retaining walls based on drilling data. At the same time, the basis of the method is core sampling by the Geobor S system (geotechnical core drilling) (Fig. 9) and its analysis in laboratory conditions [6]. The scope of the system - loose rocks, rocks of low and medium hardness.



Figure 9 - Core sampling system GEOBOR S

In addition to the method described above, it is possible to install micropiles in the form of self-drilling anchors with the MAI SDA system (Fig. 10). This method is used for the following engineering and geological tasks:

- strengthening of unstable rocks (soil);

- construction of foundations using micropiles;
- construction of tunnels [7].

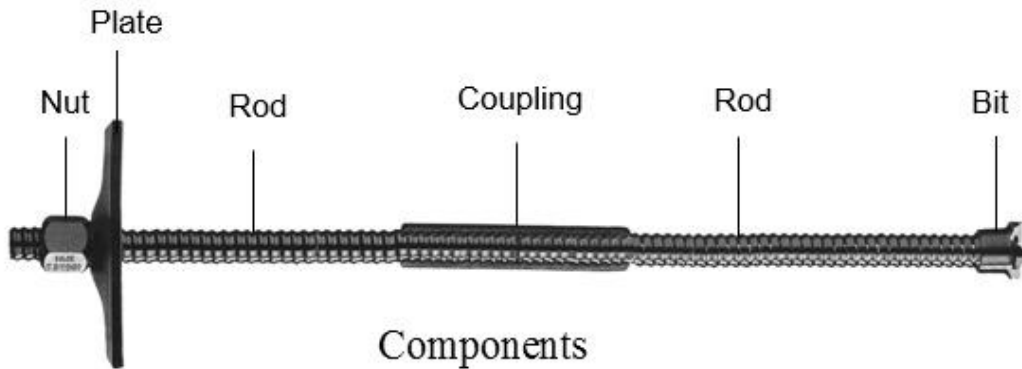


Figure 10 - Anchor MAI SDA

In geotechnical engineering, Soil and Rock Nails are used to stabilize natural or artificial slopes or to support structures e.g. retaining walls. In order to further stabilize the surface of the slope or rock, various support systems e.g. flexible reinforcing meshes or geotextiles may be installed that are held in place by the head plates of the nails. In underground applications, Soil and Rock Nails are predominantly used for fore poling, spiling, face bolting and radial bolting. The diameter of these anchors can be from 25 mm to 111 mm, with a maximum load of 200 to 3650 kN.

Self Drilling Micropiles are typically installed via simultaneous drilling and grouting using cement grout as the flushing medium. Particularly in cohesion less or unstable ground conditions e.g. sand, clay or gravel, this is the fastest and most efficient installation method for micropile systems. Compared to other methods, smaller drilling equipment can be used. Thus Self Drilling Micropiles are ideally suited for projects with limited access, confined spaces or low headroom conditions (Fig. 11 a, b).

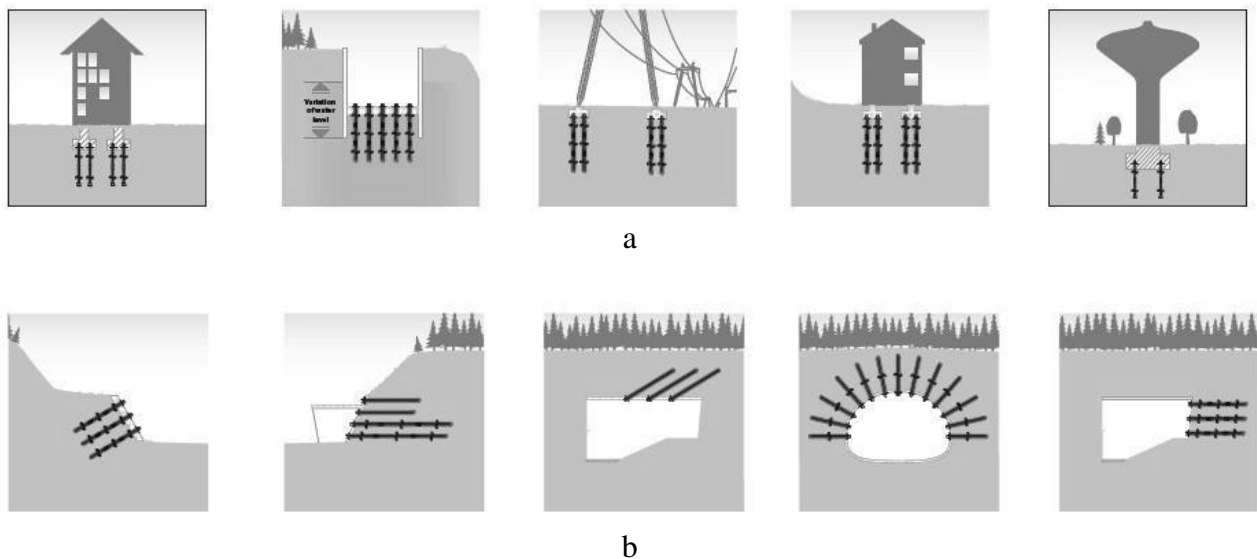


Figure 11 - The main areas of application of Self Drilling Micropiles

Symmetric simultaneous drilling system. It is used for the construction of wells in loose, unstable rocks with a diameter of 114 mm to 1219 mm. This type of drilling operations provides for the construction of piles and allows drilling without difficulty in loose rocks, loose rocks with fragments of hard rocks, which makes it possible to begin construction of piles in loose, unstable rocks and complete the construction of a well in a rocky massif by drilling it into necessary interval. The described method compares favorably with the brown-injection method in that the brown-injection method is not able to qualitatively penetrate the pile into the rock base, since the screw drilling method is designed to destroy only soft rocks (Fig. 12 a, b).

Symmetrix simultaneous drilling system is widely used in the countries of Europe in mountainous, coastal areas to strengthen the slopes and foundations of various types of structures [8].

Pile wall technology. This technology is used for construction of: retaining walls for temporary and permanent structures; combined load-bearing walls and supporting structures; combined support and supporting structures of the foundation in bridges; construction pits, basements, under intersections, embankment walls, etc (Fig. 13, 14).



a



b

Figure 12 –Start and end of drilling for a pile of 1016 mm system Symmetrix

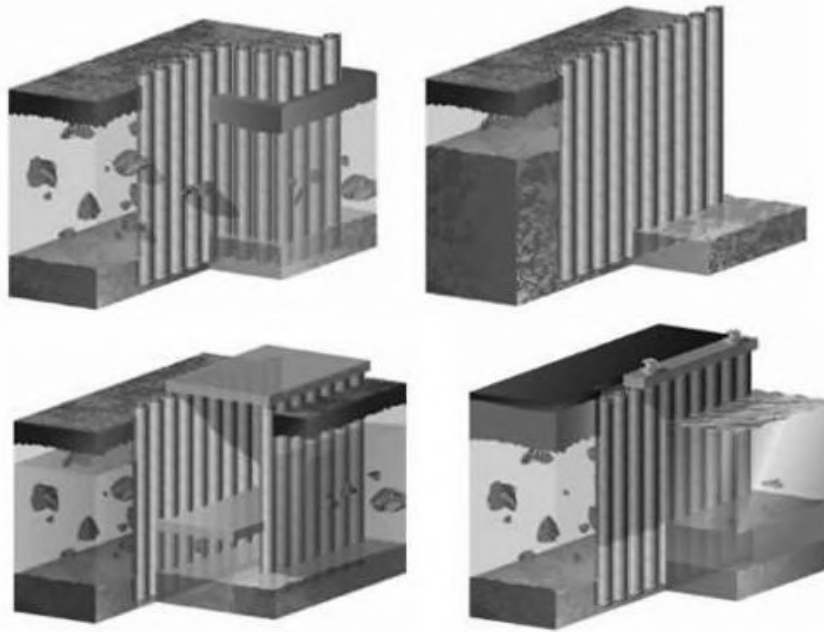


Figure 13 - Various forms of drilling casing rods

During drilling pile wall technology, the pipe bodies are fixed to each other with the help of a blocking element (Fig. 14).

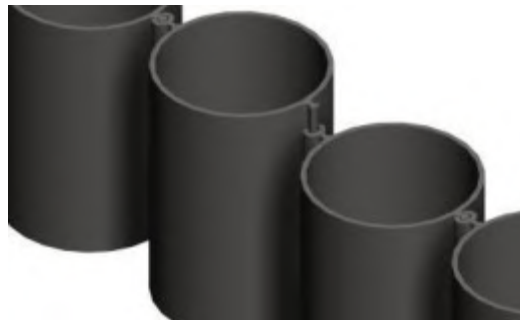


Figure 14 - Pipe clamping mechanism

An example of using this technology is the construction of a tunnel in Trondheim, Norway. The construction of the tunnel was carried out in the old part of the city, with dense blockage of buildings built on wooden piles in muddy clay. To solve the problem of soil instability and prevent damage to old buildings, 360 piles were blocked with a blocking WoM / WoF (Fig. 15, 16).



Figure 15 - Types of lock elements of pile wall technology;
a - lock type WoM/WoF; b - lock type C6



a



b

Figure 16 - Tunnel construction in Trondheim using pile wall technology

Conclusions.

1. For a rational development of the right-bank part of the city of Dnipro, an urgent task is the detailed mapping and analysis of the existing ravines and gullies.
2. To determine the stability and degree of landslide of the slopes, it is advisable to use the NIEMFE observation method, which allows to identify potentially landslide-prone slopes and areas that can be used in the urban infrastructure with low loads on the soil massif.
3. To determine the feasibility on which of the landslide-prone slopes can be applied considered technologies strengthen the boards.

REFERENCES

1. Lviv Plant of Geophysical Equipment (1984), RVINDS AHI 2.026.001 PS: Pasport radiovolnovogo indikatora napryazhenno-deformirovannogo sostoyaniya porod [Passport of the radio-wave indicator of the stress-strain state of the rocks], Lviv, SU,
2. Tyapkin K.F. and Gontarenko V.N. (1990), *Sistemy razlomov Ukrainskogo shchita* [Fault systems of the Ukrainian shield], Naukova Dumka, Kyiv, Ukraine.
3. Gursky D.S and Kruglov S.S. (2007), *Tektonicheskaya karta Ukrainy* [Tectonic map of Ukraine], State Geological Service, Kyiv, Ukraine.
4. Zmiievska K.O. (2015), *Sposob vyivleniia razryvnykh narusheniy v kristallicheskikh porodakh* [A method for identifying tectonic disturbances in crystalline rocks], Dnipropetrovsk, Ukraine, Patent № 99831 UA.
5. Zvit pro vykonannya nazemnyx zavirochnyx sposterezhen pryrodnogo impulsnogo elektromagnitnogo polya Zemli (PIEMPZ) na ploshhi svidnogo bortu Monastyrskoyi balky u m. Dnipropetrovsku (2004). Ministerstvo ekologiy i pryrodnyx resursiv Ukrainy Ukrayinskyj derzhavnyj geologorozvidualnyj instytut, Dnipropetrovske viddilennya, Bilij I.S., Dovbnich M.M., Kuzina G.P., Stovas G.M.; tema № 946-x

6. Atlas Copco Geotechnical Engineering Products. Terracore core drilling tools. (2013). Sweden. Marsta. № 6991 1799 01, 1-131.
7. Atlas Copco Rock Reinforcement Products. MAI Self Drilling Systems. (2009). Sweden. Marsta. № 6991 1571 13b.
8. Atlas Copco Ground Engineering Products. The Symmetrix Systems for the boring drilling with simultaneous plantation around. (2009). Sweden. Marsta. № 6991 1570 13b, 1-63.

СПИСОК ЛІТЕРАТУРИ

1. РВИНДС АХИ 2.026.001 ПС «Паспорт радио-волнового индикатора напряженно-деформированного состояния пород».- Львовский завод геофизического оборудования, 1984.
2. Тяпкин К.Ф., Гонтаренко В.Н. Системы разломов Украинского щита. Киев: Наукова думка, 1990. 184 с.
3. Гурский Д.С., Круглов С.С. Тектоническая карта Украины. Киев: Государственная геологическая служба, 2007.
4. Способ выявления разрывных нарушений в кристаллических породах: пат. № 99831 UA, / Змиевская К.О. № и 2015 00013; заявл. 05.01.2015; опубл. 25.06.2015, Бюл. № 12. 6 с.
5. Звіт про виконання наземних завір очних спостережень природного імпульсного електромагнітного поля Землі (ПІЕМПЗ) на площі східного борту Монастирської балки у м. Дніпропетровську; Міністерство екології природних ресурсів України Український державний геологорозвідувальний інститут, Дніпропетровське відділення, Білий І.С., Довбніч М.М., Кузіна Г.П., Стівас Г.М.; тема № 946-х, 57 с., 2004.
6. Атлас Копко Инженерно-геотехнические изделия. Инструменты для колонкового бурения Terracore. (2013). Швеция. Marsta. № 6991 1799 01, 1-131.
7. Атлас Копко Продукты укрепления пород. Системы самозабуривания MAI. (2009). Швеция. Marsta. № 6991 1571 13b.
8. Атлас Копко Продукты грунтовой инженерии. Системы Symmetrix для бурения с одновременным обсаживанием. (2009). Швеция. Marsta. № 6991 1570 13b, 1-63.

About the authors

Zmiievskaya Kristina Olegivna, Candidate of Geological Sciences (PhD), Researcher of the Department Of Technologies Of Underground Mining Of Coal Deposits, Institute of Geotechnical Mechanics named by N. Poliakov of National Academy of Sciences of Ukraine (IGTM, NAS of Ukraine), Dnipro, Ukraine, zmiievskaya@gmail.com.

Zmiievskiy Artur Stanislavovich, Master of Science, Sales Engineer RDT, LLC "Epiroc Ukraine", Kyiv, Ukraine.

Об авторах

Змієвська Кристина Олегівна, кандидат геологічних наук, науковий співробітник відділу проблем технологій підземної розробки вугільних родовищ, Інститут геотехнічної механіки ім. М.С. Полякова Національної академії наук України, Дніпро, Україна, zmiievskaya@gmail.com

Змієвський Артур Станіславович, магістр, інженер з продажу RDT, ТОВ «Епірок Україна», Київ, Україна.

Анотація. Мета. Полягає у вивченні ярово-балочної мережі міста Дніпро, визначення ступеня розвитку зсувонебезпечних явищ і виявлення можливості повернення територій ярів і балок до експлуатації.

Методика. Вивчення ярово-балочної мережі міста Дніпро проводилося шляхом рекогносцирувального дослідження, в ході якого було виконано опис бортів балок та ярів, наведено приклади ступеня їх забудови, наявність дренажної системи, перспективність їх використання. У доступних ділянках ярів та балок з метою оцінки зсувонебезпечних схилів застосовувався оперативний геофізичний експрес-метод спостереження природного імпульсного електромагнітного поля Землі приладом типу радіохвильовий індикатор пружно-деформованого стану порід.

Результати. У статті наведено аналіз стану фрагментів ярово-балочної мережі правобережної частини міста Дніпро та їх вплив на міську інфраструктуру. Розглянуто приклади успішного використання і забудови ярів будівлями і спорудами. За результатами проведеної зйомки методом природного імпульсного електромагнітного поля Землі побудована карта-схема щільності потоку природного імпульсного електромагнітного поля Землі на ділянці, що прилягає до монументу Слави, яка відображає наявність раніше засипаного яру. Проаналізовано деформаційні процеси, які спостерігаються на східному борту балки Монастирська. Розглянуто методи зміцнення схилів, що схильні до зсувів.

Наукова новизна. Вперше із застосуванням методу спостереження природного імпульсного електромагнітного поля Землі на ділянках монумента Слави та балки Монастирської побудовані карти-схеми щільності потоку природного імпульсного поля Землі, які дозволили виділити ділянки, що схильні до деформацій ґрунтового масиву та подальшим просядним процесам.

Практична значимість. На підставі виконаних досліджень можна рекомендувати застосування методу спостереження природного імпульсного електромагнітного поля Землі, який дозволяє виявляти схильні до зсувів схили та ділянки, які в подальшому можна використовувати в міській інфраструктурі при низьких навантаженнях на ґрунтовий масив.

Ключові слова: природне імпульсне електромагнітне поле Землі, ярово-балочна мережа, правобережна частина міста Дніпро, балка Монастирська, монумент Слави.

Аннотация. Цель. Заключается в изучении овражно-балочной сети города Днепр, определение степени развития оползнеопасных явлений и выявление возможности возвращения территорий оврагов и балок в эксплуатацию.

Методика. Изучение овражно-балочной сети города Днепр проводилось путем рекогносцировочных исследований, в ходе которых было выполнено описание бортов балок и оврагов, приведены примеры, степень их застройки, наличие дренажной системы, перспективность их использования. В доступных участках оврагов и балок с целью оценки оползнеопасности склона применялся оперативный геофизический экспресс-метод наблюдения естественного импульсного электромагнитного поля Земли прибором типа радиоволновой индикатор напряженно-деформированного состояния пород.

Результаты. В статье приведен анализ состояния фрагментов овражно-балочной сети правобережной части города Днепр и их влияние на городскую инфраструктуру. Рассмотрены примеры успешного использования и застройки оврагов зданиями и сооружениями. По результатам проведенной съемки методом естественного импульсного электромагнитного поля Земли построена карта-схема плотности потока естественного импульсного электромагнитного поля Земли на участке, прилегающем к монументу Славы, отображающая наличие ранее засыпанного оврага. Проанализированы деформационные процессы, наблюдаемые на восточном борту балки Монастырская. Рассмотрены методы укрепления склонов, склонных к оползням.

Научная новизна. Впервые, с применением метода наблюдения естественного импульсного электромагнитного поля Земли на участках монумента Славы и балки Монастырской построены карты-схемы плотности потока естественного импульсного поля Земли, которые позволили выделить участки, склонные к деформациям грунтового массива и дальнейшим просадочным процессам.

Практическая значимость. На основании выполненных исследований, можно рекомендовать применение метода наблюдения естественного импульсного электромагнитного поля Земли, который позволяет выявлять склонные к оползням склоны и участки, которые в дальнейшем можно использовать в городской инфраструктуре при низких нагрузках на почвенный массив.

Ключевые слова: естественное импульсное электромагнитное поле Земли, овражно-балочная сеть, правобережная часть города Днепр, балка Монастырская, монумент Славы.

Стаття надійшла до редакції 09.07.2019.

Рекомендовано до друку д-ром геол. наук В.А. Барановим.