UDC 332.3:504.064:725:624.1.01 DOI: https://doi.org/10.15407/geotm2024.168.179

INFLUENCING FACTORS AND CONDITIONS FOR THE LOCATION OF CIVIL OBJECTS WHILE RENOVATING THE MINED-OUT SPACE OF OPEN PITS

[1]*Voron O.*, [1]*Riumina D.*, [2]*Kuantay A.*

[1]*M.S. Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine*
[2]*Satbayev University*

Abstract. Theoretical studies and practical foundations of the projects by domestic and foreign scientists to renovate use of industrial facilities and integration of the disturbed territories of liquidated industrial enterprises into urban structure was analyzed. Influencing factors were systematized as well as implementation stages and renovation trends while arranging complexes of military-industrial, military-training, medical-preventive and pharmaceutical buildings during the disturbed territories of liquidated mining enterprises renovation after the war under the conditions of complex rugged topography of technogenic media in terms of an open pit. It was identified that construction technologies make it possible to implement projects to build civil objects and systems within the territories of the mined-out open pit. The key idea of such a project implementation is to take into consideration its following components: "factors influencing the development object"; "implementation stages"; and "renovation trend". The abovementioned helped propose to improve classification of the complex arrangement depending upon the mining and geological conditions. The authors developed alternatives to arrange groups of civil and military objects (i.e. buildings and structures) within the mined-out open pit territory taking into consideration 7°–40° terrain slope being the most reasonable from the viewpoint of economic and engineering factors.

The paper recommends performing preliminary geomechanical substantiation of a solid mass stability using software systems to simulate stress-strain state of the rock mass. If geomechanical stability of the solid mass, where it is scheduled to carry out construction operations to build objects, is not available then it is recommended to implement anti-slip measures through innovative decisions.

In the context of recovery of Ukraine, the disturbed soil renovation under the conditions of technogenic terrain becomes the important step towards sustainable development of the country, and support of environmentally friendly production. The abovementioned will favour formation of new territories for human life and activities; improvement of infrastructure and social welfare of people; mitigation of environmental risks; and environmental enhancement.

Keywords: influencing factors, renovation of the disturbed land, mined-out area of an open pit, civil facilities, anti-slip measures.

1. Introduction

After military operations with the Russian Federation are over, renovation of Ukraine is the priority issue. The modern towns and cities can be characterized by a "spatial chaos" term. Resulting from a military load (explosions, fires etc.), the land experiences serious erosion impact; at the same time, building loses functions as for their use. Territories of Kryvyi Rih, Nikopol, Marhanets and other mining enterprises are among environmentally hazardous and problematic as for the disturbed land renovation. Stable development of the areas involves decrease in anthropogenic load on the towns and restoration of productivity of the disturbed land as well as aesthetically valuable landscapes. The trends are the relevant components in the urban renovation projects to be implemented after the war.

2. Methods

The theoretical research method (abstraction, classification, analogy, etc.) was used to assess the factors of influence and conditions for the location of civilian objects in the renovation of the quarry space.

Experts from research institutes, State institutions of higher education, and research centres propose a number of programs and projects; organizational and technical decisions; and innovative approaches to meet defence requirements, renovate the disturbed land, and develop national infrastructure. Within the Program of Strategic Urban Planning up to 2030, the European Union (EU) mentioned the possibility to make strategic projects for the development and urban planning in Ukraine supported by the EU structural and investment funds [1, 2].

Currently, Ukrainian system of urban planning differs significantly from the European model though it is intended to achieve stable development goals. It implements projects of extensive urban development, which means attraction of resources for potential revitalization of mining and industrial enterprises.

The purpose is to substantiate theoretically influencing factors as well as stages of implementation as for arrangement of complexes of military-industrial, military-training, medical-preventive and pharmaceutical buildings during the disturbed territories of liquidated mining enterprises renovation after the war.

3. Theoretical and/or experimental parts.

Problematics of renovation or revitalization in its socioeconomic interpretation is rather innovative tendency for domestic science. The term was first applied in biotechnologies to define regeneration processes, and in architecture to characterize measures connected with renovation of buildings. Cambridge Dictionary, 2020 interprets revitalization as a process of making something grow, develop, or become successful again.

Billert (2005), Kaczmarek (2001), Parysek (2005), and (Leary&McCarthy, 2013) as well as such domestic scientists as O.M. Rudenko (2016), O.A. Sych (2020), T.V. Tabolyna (2004), Yu.I. Haiko, Ie.Yu. Hnatchenko, N.A. Samoilenko & O.V. Petrovska (2021), O.V. Chemakina & Kravchenko (2015), K.S. Kharchenko & V.I. Chorna (2021) and others were engaged in the problem. Some scholars mentioned priority of historical, cultural, social (inclusive of those ones concerning spheres of education and health) and other aspects in the process of urban renovation (Couch, Sykes, & Börstinghaus, 2011; MacGregor, 2010).

Following approaches are applied in the process of industrial facility renovation: retirement of some structures used in the industrial cycle and its substitution for newer and more advanced models; reconstruction of enterprises on the whole or their separate subdivisions involving replacement of the worn-out objects with more contemporary ones; and complete liquidation of old facilities to construct new ones instead [3–8].

Global analysis of the revitalization process showed its focusing on solving the problems of crisis areas, and urban territories taking into consideration geopolitical situation as well as the regulatory field being typical for the specific state. For the last four decades, more and more often buildings are designed within the territories, which are less suitable for construction due to such terrain features as ravines, gullies, steep slopes, open pits, tailings ponds, industrial sites of the liquidated mines etc. The abovementioned is seen in a number of the implemented revitalization and renovation world projects where the majority of industrial objects become ***polyfunctional centres***, i.e. those ones performing several socially useful functions. The following can be used as an example: transformation of lignite open pits south of Leipzig into lakes where houseboats are the key attraction (Germany); and construction of the municipal stadium of Braga within the mined-out area of granite open quarry (Portugal). The current projects are as follows: development of artificial lake in a sulphur open pit (Miechów, Poland); construction of *Ecocity 2020* in the pit of a diamond quarry *Mir* (Yakutia); ecocity location within a molybdenum ore quarry (Yerevan, Armenia); construction of exotic Shimao Hotel inside 100-m depth lime open pit partially filled with water (Songjian, China); a project of post-mining terrain formation during extraction operations in *Motronivka* open pit (Dnipropetrovsk Region, Ukraine); a revitalization project for *Kadykivsky* quarry (2005–2006, town of Balaklava, Autonomous Republic of Crimea, Ukraine); a renovation project for geological environment within a sinkhole while conserving sites of *Nova* mine (town of Zhovti Vody, Ukraine); a pilot project for ecological industrial park *Kryvbas* to process sludges (town of Kryvyi Rih, Ukraine); and an industrial park *Solomonovo* (Transcarpathian Region, Ukraine). *Monofunctional centres* are also available, namely multi-storey house-hostel for 226 apartments “Silo silo” located in place of a grain elevator; small houseboats for people within artificial and natural reservoirs (the Netherlands); and an ancient sculpture museum in the building of a former thermal power station “Centrale Montemartini” (Rome, Italy) [9–11].

In our paper, we highlight prospects of the disturbed land renovation as for the development of civil objects (complexes) within the territories of the liquidated mining enterprises, where the complicated terrain is available, in terms of open pits during renovation of Ukraine.

4. Results and discussion

According to the State Classifier of Buildings and Structures *ДК 018-2000,* open pit is an industrial facility belonging to engineering complexes [12].

The open pits, where iron ore or building material are extracted, located either in towns or their suburbs, differ in area; composition of rocks (sandy, clay, limestone, mixed etc.); occurrence depth of ground water (dry, water-flooded, temporarily water-flooded); and shape of the mined-out surface (with flat or stepped bottom, with internal or external dumps). As a result, open pits, differing in the shape of their mined-out surface, were formed in the towns during different historical periods.

In accordance with legislation of Ukraine, future use of the territories needs either reclamation or renovation depending upon the selected functional application. Reclamation trend is identified relying upon a decision as for potential functions of the reclaimed mined-out area and depending upon the open-pit development operations.

Analysis of domestic and world practices concerning design and construction of civil buildings and structures within the complex terrain (i.e. the mined-out open pit area), helped identify that spatial scheme of a building structure depends on the object typology; geometry of the quarry and its other parameters; arrangement of the open pit relative to the town or the town centre; availability of recreation areas, investment potential; and desires of the customer. In the majority of cases, objects of future development are formed along the open pit walls; if the open pit is closed then entrance areas are arranged from its upper edge; if not, then entrance areas are arranged from its bottom [13].

Within settlements and towns, adjoining territories of the liquidated mining enterprises, either *combined* or recreational and construction trend is topical and popular. The trend helps return quarry areas to urban infrastructure not as an industrial structure but as an object making it possible to compose recreation facilities with nonindustrial civil structures and buildings [14].

Under the conditions of the post-war period, we recommend construction of military-industrial, military-training, medical-preventive and pharmaceutical etc. buildings for the development of cities, towns, and their suburbs. While making the projects under the conditions of the complicated terrain, it is recommended to take into consideration following key components (i.e. factors, influencing the development object; implementation stages; and renovation trend) for the specific technogenic terrain of the disturbed environment. The factors influencing the development object can also be divided into external (i.e. natural and climatic, ecological, urban planning, socioeconomic, historical and ethnic, and geopolitical) and internal (functional and technological, engineer and technical, and aesthetic).

Fig. 1 shows the systematized factors of influence, implementation stages, and renovation trends while arranging development objects under the conditions of the complicated terrain of technogenic deposits in terms of an open pit. Materials of [5, 13–17] were used.

Natural and climatic factors are the most important external agents. Topographic and geological aspects of the natural and climatic factor of influence are the defining conditions impacting object formation if the terrain is of a complex nature. The matter is that such their components as area, configuration in plan, composition of enclosing rocks, occurrence depth, steepness of the terrain, slope type, the quarry microclimate, and the solar illumination of the slopes define characteristic of hardness of the territory development. In turn, components of the socioeconomic factors prove expediency of the open pit renovation.

Engineering and technical factors are the most important ones among the internal agents. The organized implementation of the components of communication processes involves the following: minimization of terrain differences; slope terracing and strengthening; application of approaches for height differentiation of the objects taking into consideration the principle of accessibility to the bottom of the open pit; and optimization of transport connections.

The analysis of scientific papers and projects as for theoretical and practical experience of implementation stages while constructing objects within the territories of open pits and their dumps helped understand that solving the problem concerning arrangement of civil and military group of objects (i.e. buildings or structures) at the territories of the liquidated or abandoned mining enterprises first involves slope of the specific site as well as average slope of the quarry walls. Construction activities take place within the areas being the most comfortable and safe from the viewpoint of the development [18,19].

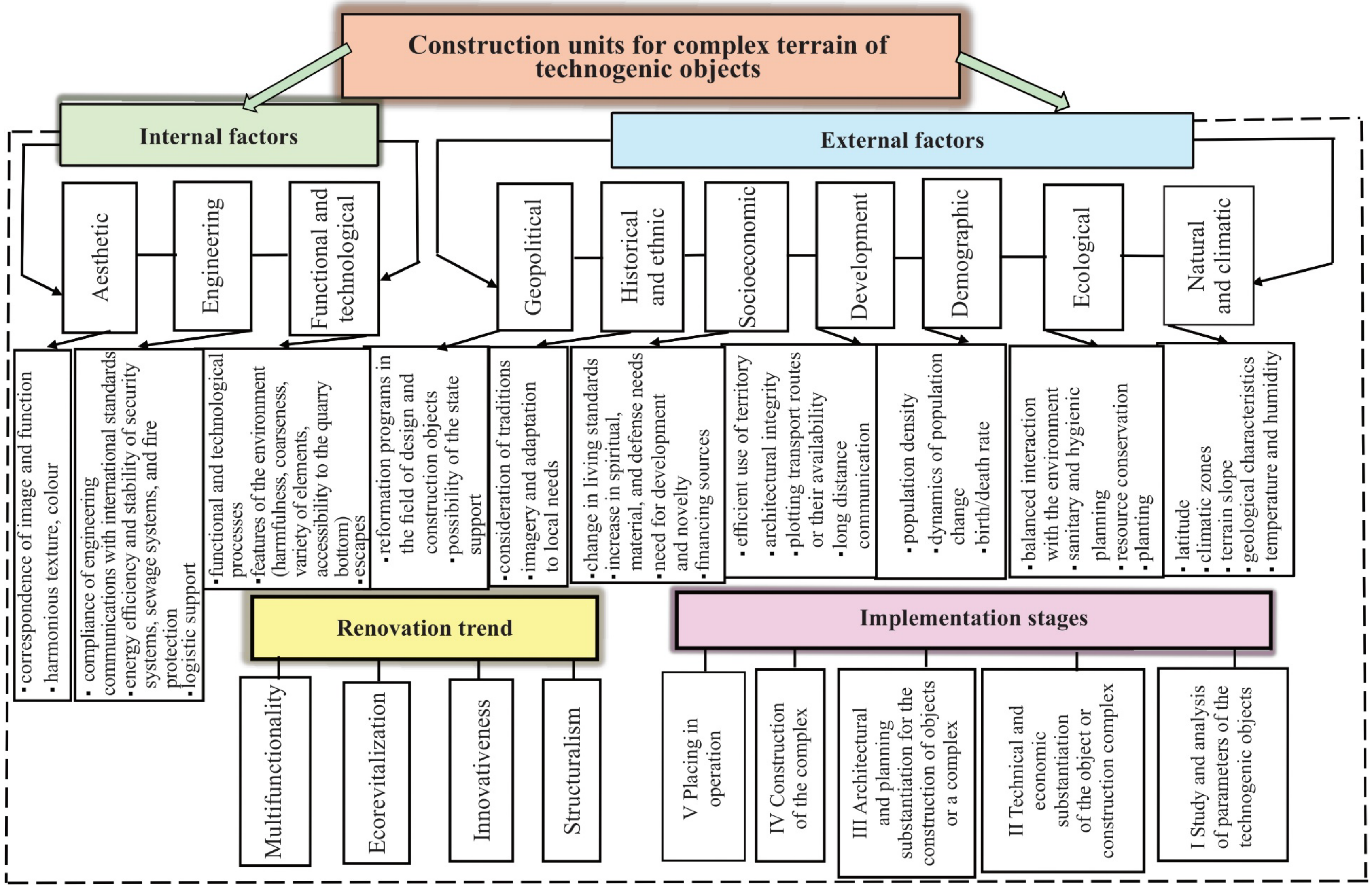


Figure 1 – Systematization of the influential factors, implementation stages, and renovation trends while arranging building complexes for the complicated terrain within a quarry

Within industrial sites being potentially unsafe in terms of their geomorphological characteristics construction activities take into consideration strengthening measures for the slopes and basement. The areas, being the most dangerous and inaccessible ones from the engineering standpoint, are preserved as the landscaping and recreational zones. Alternatives to build facilities in the technogenic terrain depend upon lithology or geological composition of the rock mass; structure and tectonics of enclosing rock mass; availability of aquifers; physicomechanical characteristics of rocks forming the selected area mass etc.

Analysis of scientific papers concerning construction projects [17, 20] made it possible to identify the basic arrangement alternatives for military-industrial, military-training, medical-preventive and pharmaceutical buildings and structures. Author of paper [20] proposed to plan future complexes taking into consideration 7°–40° terrain slope as the most adequate angle from the economic and engineering viewpoint.

The abovementioned helped propose the improved classification for the arrangement of complexes relying upon mining and geological conditions. Table 1 explains the alternatives to arrange groups of buildings and structures.

According to the data from Table 1, it is recommended to construct buildings within quarry slopes and walls (where sedimentary rocks prevail) using schemes 1, 4, 5, and partially 7 if basement and supporting walls have extra strengthening. Schemes 2, 5, 7, and 8 are applied if crystalline and sedimentary rocks are mixed. In the context of the schemes, the foundation basis will be located on crystalline rocks; upper storeys and side walls will be placed at the level of sedimentary rocks. Schemes of buildings, numbered as 3, 6, and 9, can be applied if only crystalline rocks occur.

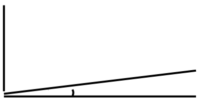
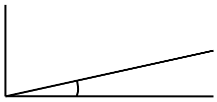
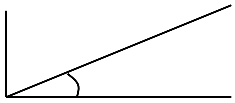
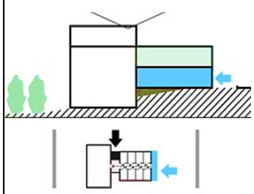
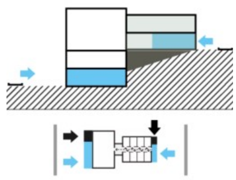
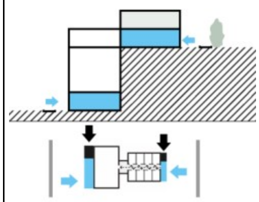
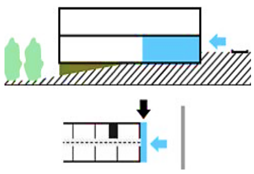
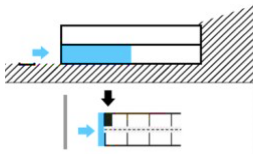
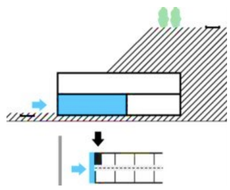
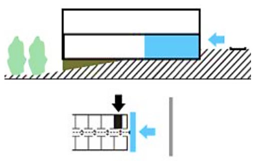
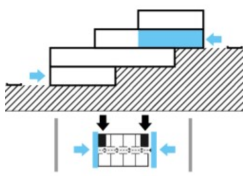
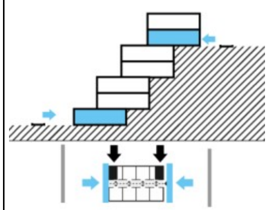
It should be mentioned that depending upon the rock extracted in the open pit, following schemes to form foundations are used for future objects:

1) shallow foundation schemes;
2) deep foundation scheme; and
3) scheme of anchorage foundation [21].

Construction of a future building object within a quarry slope stipulates the necessity to take into consideration features of physicomechanical soil characteristics; implementation of anti-slide measures; fire safety control; and protection against precipitation.

While forming infrastructural object within slight slopes of a quarry walls, it is required to analyze intensity of geomechanical processes, define rules of their progress, and identify operational risks. Bearing capacity of the quarry walls and bench slopes should be calculated. Consequently, such calculations are required to understand what load they can take by any building planned to be constructed. The operations are recommended to be performed using the specific software modules of geoinformation and mining-geological systems. For example, use of such a software complex as “K-MINE: calculating stability” for open pits where mining with deepening takes place for deposits differing in steep or easy gradient. In the context of the software complex, stability of quarry walls and levels of internal dumps is defined through a geomechanical problem solving with identification of a stability margin factor with maximum permissible parameters.

Table 1 – Arrangement of civil and military groups of objects* (buildings and structures) within the mined-out areas of a quarry involving its terrain slope

Slope (according to V.R. Krogius) / Groups of objects (structures and buildings), their external view, and scheme	moderate 4°–7° 	intensive 8°–23° 	steep 23°–40° 
Physical training complexes *Ukrainsky Lehion*. Professional military educational and training institutions 	1 	2 	3 
Buildings of medical and preventive institutions. Rehabilitation complexes. Military equipment warehouses. Facilities to store mobile MLRSs 	4 	5 	6 
Mini factories (workshops) manufacturing technical equipment for people with limb amputations. Stationary and modular research medical and pharmaceutical laboratories. 	7 	8 	9 

*The authors have systematized and processed the data relying upon information by M.O. Rudenko [13,20]

** Symbols

Emergecy exit/entrance	Entrance for visitors and personnel	Entrance area	Basic premises (rooms, halls)	Corridor grouping of the premises	Road

Hence, the specified parameters are the basis to develop a sliding surface helping determine the stability margin factor. Tabulated report is formed according to the calculation results; the information in the form of a map of stability margin coefficients is represented graphically. Then the maximum permissible slope of a wall (wall section; bench and level) ensuring the required stability margin is calculated in accordance with the standard value of the stability margin factor $\eta = \eta_{norm}$ [22].

In turn, to design future foundation arrangement it is better to apply load distribution scheme within the stress-strain rock mass using a software of finite-element analysis “Phase-2” [23]. Relevant construction parameters are substantiated relying upon the simulation results of the strain-stress rock mass state. In this regard, determination of the maximal permissible slopes takes into consideration a measure to arrange the wall or its section within the specified periphery.

Further, implementation of anti-slide measures is required. They are taken as follows: soil stabilization at the slide surface; formation of sealing curtains in front of landslide areas; and soil surface strengthening. Among the groups of events, listed in *ДБН В.1.1-46:2017* [24] and recommended to be applied under the specific conditions of structural and plastic as well as detrusive landslides within an open pit wall while forming foundations of construction objects and complexes the following should be separated:

1) retaining anti-slide foundations;
2) avalanche structures, namely:
   - supporting frameworks and walls; and
   - buttresses, seals and belts;
3) avalanche measures, namely:
   - anchorage (to be fastened to hard rock mass);
   - geosynthetical casing with anchoring throughout the sliding mass height;
   - supports and connectors;
   - liquid anchors (injecting by means of cohesive materials to prevent from weathering and breaking down);
   - combined structures;
   - catching devices;
   - change in slope terrain, and decrease in slope inclination; and
   - chemical sealing of the sliding foundation rocks.

Rock mass anchoring from a quarry inside is dangerous for performers. Deep-laid anchors need previous geophysical analysis of the wall as well as the use of cohesive materials.

Approaches to a building constructed within a slope can be controlled from the level of a quarry periphery; however, fire fighting vehicle approach to the quarry bottom should be involved through benches if the building is within a terracing. Thoroughfares should also be organized in accordance with *ДБН В.2.2-9-2009* requirements [25].

Buildings in open pits should be protected against precipitation by means of measures being typical for structures within the complex terrain, i.e. polymer drainage pipes; and substructure protection with the help of water-proof membranes.

Procedure of evacuation to benches involves exits at each level along blocks with vertical communications. In such a way, visitors and personnel can leave the building and evacuate from the quarry area through emergency stairs.

4. Conclusions

In the context of recovery of Ukraine, the disturbed soil renovation under the conditions of technogenic terrain becomes the important step towards sustainable development of the country and support of environmentally friendly production. The abovementioned will favour formation of new territories for human life and activities; improvement of infrastructure and social welfare of people; mitigation of environmental risks; and environmental enhancement. To advance the tendency, it is required to implement complex approach (namely, adoption of law “On Revitalization”), and develop relevant program.

Construction techniques make it possible to implement project as for building of civil objects and complexes within complicated terrain sites at the territories of the liquidated mining enterprises. The basic condition for implementation of such project is to involve following key components as factors, influencing the development object; implementation stages; and renovation trend for the conditions of the specific technogenically disturbed environment.

The objects arranged within complex technogenic terrain have certain construction difficulties which needs geomechanical substantiation of the body stability. To solve the problem, it is proposed to use software complexes modelling stress-strain state for determination rational parameters of the body configuration as well as construction structure.

If geomechanical stability is not available within the area, where construction activities are planned, then anti-slide measures are required which can be done while implementing innovative decisions. First of all, the rise should be strengthened before building operations start through supporting walls or terracing. Following step is to take measures favouring termination of structural and plastic as well as detrusive slides within a quarry walls. For the purpose, anchors; geosynthetical casing with anchoring throughout the sliding mass height; and liquid anchors (i.e. injecting by means of cohesive materials to prevent from weathering and breaking down) should be applied. It is also important to take care of qualitative moisture proofing and drainage to protect against ground and surface water.

REFERENCES

1. Sych, O.A., Sytnyk, N.S., Stasyshyn, A.V. and Kruhliakova, V.V. (2023), "*Urban revitalization – the EU experience for Ukraine*". Lviv: Ivan Franko LNU. Available at: https://financial.lnu.edu.ua/wp-content/uploads/2023/12/maket_Revitalizatsiia-mist.pdf (Accessed 7 March 2024).

2. Law of Ukraine "*On the Control of Town-Planning Activities*" of 23 November 2011, № 2628 -USh. Official Messenger of Ukraine, (2011), no.18, p. 131. Available at: https://zakon.rada.gov.ua/laws/show/3038-17#Text (Accessed 7 February 2024).

3. Sych, O. A., (2020), "Revitalization as a component of a city strategy", *Messenger of V.N. Karazin Kharkiv National University. Economic Series,* (99), pp. 66–73, https://doi.org/10.26565/2311-2379-2020-99-07

4. Haiko, Yu.I., Hnatenko, Ye.Yu., Zavalny, O.V. and Shyshkin, E.A. (2021), *"Renovatsiia promyslovoi zabudovy ta yii adaptatsiia do suchasnoho miskoho seredovyshcha"*, [Renovation of industrial development and its adaptation to the current urban environment], KhNUCE named after O.M. Beketov, Kharkiv, Ukraine.

5. Kravchunovska, K.S., Bronevytsky, S.P., Kovaliov, V.V. and Zaiats, Ye.I. (2017), "*Features of industrial enterprise reconstruction taking into consideration of the development territory value*", *Construction, material science, machine-building*, no. 99, pp. 101–106, available at: http://smm.pgasa.dp.ua/article/viewFile/105004/100152

6. Kaczmarek S., (2001), *Rewitalizacja terenów poprzemysłowych. Nowy wymiar w rozwoju miast*, [Revitalising brownfield sites. A new dimension in urban development], Wydawnictwo Uniwersytetu Łódzkiego, Łódź, Poland.

7. Billert, A. (2005), "*The ancient urban center in Zary. Problems, methods and strategies of revitalization*", available at: http://www.zary.pl/PL/39/72/Problemy_rewitalizacji_Centrum_Staromiejskiego_wZarach/k/ (Accessed 30 March 2024].

8. Kirsanov, M., Diakun, I., Ruban, V., Skosyriev, V. and Zhevzhyk, O. (2020), "*Estimation of usage efficiency of freon-steam turbines in mine energy complexes*", In: II International Conference Essays of Mining Science and Practice (RMGET 2020), Dnipro, Ukraine, no. 168, https://doi.org/10.1051/e3sconf/202016800048

9. Bulat, A.F., Chetverik, M.S., Bubnova, Ye.A. and Levchenko, Ye.S. (2018), "Use of Geological Environment Disturbed by Open Excavation: Problems and Prospects", *Metallurgical and Mining Industry*, no. 3, pp. 46–53. DOI: http://www.metaljournal.com.ua/read/en/2018/3/.

10. Chetveryk, M.S., Bubnova, Ye.A. and Soroka, Yu.N. (2013), "Reasons of formation and trends to liquidate rockfalls resulting from mine workings", *Geo-Technical mechanics*, no. 111, pp. 190–202, Available at: http://dspace.nbuv.gov.ua/handle/123456789/87359

11. Voron, O.A. (2023), "Modern approaches to the creation of the infrastructure on the territory of the liquidated man-made and industrial facilities in the mining regions" [Modern approaches to the creation of the infrastructure on the territory of the liquidated man-made and industrial facilities in the mining regions], *Tezi dopovidey XXI conf. molodykh vchenykh: Heoteknichni problemy rozrobky rodovyshch* [Conference of Young Scientists Geotechnical problems of Deposit Mining], October 26, 2023, Dnipro, Ukraine.

12. Limited Liability Company "Agency of Geospatial Decisions Areopa" (2023), "*The National Classifier of Buildings and Structures НК 018:2023*" [online], Kyiv: Ministry of Economy of Ukraine, available at: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=105599 (Accessed 18 April 2024).

13. Rudenko, M.O. (2014), "Theoretical model to organize civil buildings and structures formed under the complicated conditions (in terms of quarries*)*", *Urban development and territory planning*, no. 51, pp. 502–506, available at: https://library.knuba.edu.ua/books/zbirniki/02/201451.pdf

14. Voron, O.A. (2011), "Technogenic disturbances of the environment during final stage of mineral extraction in quarries and their renovation tendencies", *Geo-Technical mechanics*, no. 95, pp. 30–36.

15. Voron, E.A. (2012), "Recreational trend for reclamation of open pits located within industrial areas", *Geo-Technical mechanics*, no. 103, pp. 76–82, available at: http://dspace.nbuv.gov.ua/bitstream/handle/123456789/54153/10-Voron.PDF?sequence=1

16 Bubnova, E. A., Babyi, E. V., Voron, E. A., (2015), "Ways to address the challenges of operating enrichment waste stockpile" [Ways to address the challenges of operating enrichment waste stockpile], *International conference 'Miners' Forum 2015': Proceedings of the international conference,* Dnipropetrovsk, 30.09 – 03.10.2015, Dnipropetrovsk: NHU, no. 1, pp. 211–219.

17. Kravchenko, O.V. (2010), "Features of forming open urban spaces containing disturbed areas in the planning structure of urban formations of Donbas", *Modern problems of architecture and urban planning*, no.23, pp. 234–242, available at: https://library.knuba.edu.ua/books/zbirniki/01/201023.pdf.

18. Slashchov, I., Shevchenko, V., Kurinnyi, V., Slashchova, O. and Yalanskyi, O. (2019), "Forecast of potentially dangerous rock pressure manifestations in the mine roadways by using information technology and radiometric control methods"*, Mining of Mineral Deposits*, no.4, pp. 9–17, https://doi.org/10.33271/mining13.04.009

19. Babii, K., Chetveryk, M., Perehudov, V., Kovalov, K., Kiriia, R. and Pshenychnyi, V. (2022), "Features of using equipment for in-pit crushing and conveying technology on the open pit walls with complex structure", *Mining of Mineral Deposits*, (16) 4, pp. 96–102, https://doi.org/10.33271/mining16.04.096

20. Rudenko, M.O. (2017), "Architectural and planning organization of public buildings and structures on the territory of reclaimed quarries (on the example of Kryvbas)", PhD dissertation, National University "Lviv Polytechnic", available at: https://lpnu.ua/spetsrady/d-3505211/rudenko-mariia-oleksandrivna

21. Shutenko, L.M., Rud, O.H., Kichaieva, O.V. et al. (2017), "*Soil mechanics, foundations and foundations*". Kharkiv: KhNUMG named after O.M. Beketov, Kharkiv, Ukraine.

22. Nazarenko, N.V. (2018), "*Geomechanical modeling of mining and technical objects in kmine as a component of minimizing the consequences of land disturbance during mining operations*". In: Fifth International Scientific and Practical

Conference “Subsoil Use in Ukraine. Investment Prospects” (8–12 October 2018), Truskavets, 2018, pp. 89–91, available at: http://conf2018.dkz.gov.ua/files/2018_materials_vol_2_net.pdf

23. Kovrov, O., Babiy, K., Rakishev, M. and Kuttybayev, A. (2016), “Influence of watering filled-up rock massif on geomechanical stability of the cyclic and progressive technology line”, *Mining of Mineral Deposits*, no. 10, Issue 2, pp. 55–63, https://doi.org/10.15407/mining10.02.055

24. State Enterprise “State Research Institute of Building Structures” (NDIBK) (2017), “*Engineering protection of territories, buildings and structures and landslides. Basic provisions. DBN V.1.1-46:2017*” [online], Kyiv: Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine. 13 p, available at: https://online.budstandart.com/ua/catalog/doc-page.html?id_doc=72096 (Accessed 18 April 2024).

25. State Enterprise “*Ukrainian Research and Design Institute of Civil Construction*” (2018), “Public buildings and structures. Basic provisions. DBN V.2.2-9:2018” [online]. Kyiv: Ministry of Regional Development, Construction and Housing and Communal Services of Ukraine. 47 p, available at: https://dbn.co.ua/load/normativy/dbn/1-1-0-405 (Accessed 20 April 2024).

About the authors

Voron Olena, Master of Sciences, Engineer in Department of Geomechanics of Mineral Opencast Mining Technology, M.S. Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine (IGTM of the NAS of Ukraine), Dnipro, Ukraine, olenav2945@gmail.com, ORCID ***0000-0003-1977-114X***.

Riumina Daria, Master of Sciences, Engineer in Department of Geomechanics of Mineral Opencast Mining Technology, M.S. Poliakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine (IGTM of the NAS of Ukraine), Dnipro, Ukraine, Darya445@gmail.com, ORCID ***0009-0005-2502-1144***.

Kuantay Aidana, Doctoral Student of the Mining Department, Satbayev University, Almaty, Kazakhstan, kuantay.aidana@bk.ru, ORCID ***0000-0001-5703-8227***.

ФАКТОРИ ВПЛИВУ І УМОВИ РОЗТАШУВАННЯ ОБ”ЄКТІВ ЦИВІЛЬНОГО ПРИЗНАЧЕННЯ ПРИ РЕНОВАЦІЇ ВИРОБЛЕНОГО ПРОСТОРУ КАР’ЄРІВ

Ворон О., Рюміна Д., Куантай А.

Анотація. Проведено аналіз теоретичних досліджень і практичних основ проектів за напрямком реновації використання промислових споруд та інтеграції порушених територій ліквідованих промислових підприємств до міської структури, створених вітчизняними і зарубіжними вченими. Виконано систематизацію факторів впливу, етапів впровадження і напрямів відновлення при розташуванні комплексів споруд військово-промислового, військово-навчального, медично-профілактичного і фармацевтичного призначення при реновації порушених земель територій ліквідованих гірничодобувних підприємств у післявоєнний час для умов складного рельєфу техногенних середовищ на прикладі кар’єра. Встановлено, що будівельні технології дозволяють впроваджувати проекти по будівництву об’єктів і комплексів цивільного призначення на території виробленого простору кар’єра. Головною умовою при впроваджені таких проектів єураховувати наступних основних його складових «Фактори впливу на об’єкт забудівлі», «Етапи впровадження» і «Напрямок реновації». На підставі чого запропоновано вдосконалити класифікацію розташування комплексів за гірничо-геологічними умовами. В статті розроблені варіанти компонування груп об’єктів (будинків і споруд) цивільного і військового призначення в просторах відпрацьованого кар’єру з урахуванням кута ухилу рельєфу в межах від 7° до 40° як найбільш раціонального за економічними і інженерно-технічними факторами.

В роботі рекомендовано попередньо проводити геомеханічне обґрунтування стійкості масиву, використовуючи програмні комплекси моделювання напружено-деформованого стану масиву. В разі встановлення відсутності геомеханічної стійкості масиву, на якому заплановано виконувати будівельні роботи по створенню об’єктів, рекомендовано впровадження протизсувних заходів за допомогою інноваційних рішень.

Ключові слова: фактори впливу, реновація порушених земель, вироблений простір кар’єру, об’єкти цивільного призначення, борт кар’єру, протизсувні засоби.