Landslide25_13

Activation of exogenous processes during the construction of structures beside wells

***B. Stasiv** *(Ivano-Frankivsk National Technical University of Oil and Gas)*, **N. Goptarova** *(Ivano-Frankivsk National Technical University of Oil and Gas)*, **L. Uhrak** *(Ivano-Frankivsk National Technical University of Oil and Gas)*, **M. Medvid** *(Ivano-Frankivsk National Technical University of Oil and Gas)*, **O. Paliychuk** *(Ivano-Frankivsk National Technical University of Oil and Gas)*

SUMMARY

This work aims to establish changes in the engineering and geological conditions of the areas adjacent to the oil and gas wells, and threats to the activation of exogenous processes. Analytical research methods (analysis of literary sources and fund materials) and experimental methods were used in this work. Due to the drilling of wells with the selection of monoliths and soil samples, the following results were obtained: a diagram of the location of wells, boundary marks of engineering-geological elements EGE, soil stratification, soil samples for laboratory research. Laboratory studies of physico-mechanical properties of soils allowed us to obtain their physico-mechanical characteristics, and thanks to office studies – an engineering-geological cross-section was obtained. The results obtained in the work complement the knowledge of the geological structure of this region and Scubova zone of the folded region of Ukrainian Carpathians and are recommended for use in the construction of structures beside wells.

Introduction

The relevance of this research stems from the urgent need to ensure a stable supply of hydrocarbon resources to the industrial sector. In the current context, developing domestic hydrocarbon deposits is considered a key step toward meeting industrial demand and enhancing Ukraine's energy independence. One such deposit is the 914-Pasichna oil well, around which a complex of auxiliary facilities is planned for operational support. To support this development, a comprehensive program of engineering and geological investigations must be carried out to obtain detailed information about the geological conditions within the construction site.

The engineering and geological conditions of the area are primarily influenced by topography, soil composition and properties, and the characteristics and depth of groundwater. A range of geological processes may be triggered by changes in these conditions, including foundation settlement due to soil compaction, subsidence resulting from leakage in aqueducts and water infiltration from canals, deformation of artificial slopes, riverbank and reservoir erosion, as well as collapses and landslides during underground construction works (Demchishin, 2004).

Accordingly, the research aims to study the geological structure of the project construction site, study the physical-mechanical and filtration properties of soils, determine the groundwater level, and assess and forecast the development of adverse physical-geological processes (Zhiriy et al., 2019).

Method and/or Theory

The section of operational well № 914-Pasichna was selected for research to predict changes in engineering and geological conditions during the construction of structures beside wells. Administratively, the search site is located on the lands of the Bytkiv village council of the Nadvirna district. In terms of geomorphology, the research area is located within the boundaries of the Nadvirnyan structural erosive low-hill terrain of the Precarpathia (Gabinet et al.,1976).

The construction site of production well № 914-Pasichna is located on the eastern slope of one of the peaks. The indicated slope refers to the catchment area of the Bytkivchyk river. The topography of the area where the search is conducted is gently sloping. Some sections of the slope of the western territory have artificially created precipitous ledges of medium steepness. As a result of the construction of platforms (shelves) for the placement of drilling equipment and structures, the slope's surface is complicated by local fragments of cuttings and deposits of displaced soil on the root slope. The tower-winch block and adjacent buildings are located on the lower wide shelf, characterized by a significant development of bulk soils.

Results

During the reconnaissance survey of the work site and the adjacent territory, signs of flooding of the site of the tower-winch block and the adjacent structures were found. Signs of the specified physical and geological phenomenon were manifested in the significant spread of water-saturated artificial soils and the development of solifluction displacements (local surface movements of over-moistened soils) on the eastern edge of the slope (h=3.0 m), composed of bulk soils. The main reason for the development of flooding and the partial manifestation of accompanying adverse physical and geological processes is the lack of organized interception and drainage of slope and atmospheric waters from the leading construction site, created as a result of planning works, mainly from bulk soils.

In conducting field engineering and geological works, five technical wells were drilled with the selection of soil samples for laboratory research.

The geodetic service of SRPI (Scientific Research Project Institute) has mapped the mine workings in plane and elevation and plotted them on a copy from the M 1: 500 topographic plan (Fig. 1).

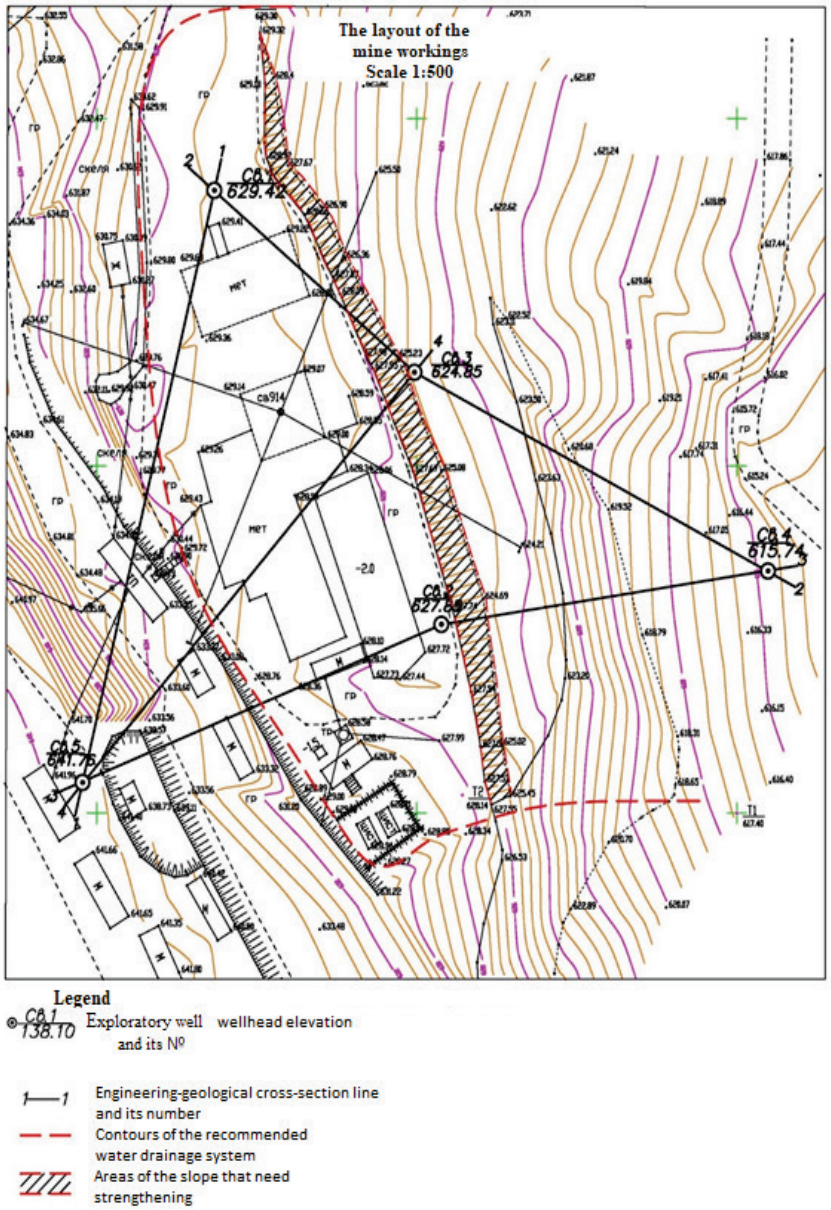

Figure 1 *The layout of the mine workings the lands of the Bytkiv village council of the Nadvirna district*

The engineering-geological cross-section of the site of the project works has been investigated to a depth of 10.0 m. It is represented by Quaternary eluvial-deluvial, clastic-clay sediments, which lie on menilitic rocks of the Lower Oligocene.

In the cross-section, 5 engineering-geological elements (EGE) are highlighted:
EGE № 1 - The distribution of artificial soils is caused by cutting the slope with the subsequent planning of production sites. Since the depth of soil freezing for this research area reaches 0.9 m, construction in the areas of distribution of bulk soil with a thickness of less than 0.9 m is possible only when choosing a "floating" slab foundation, the strength of which will be sufficient to withstand the action uneven forces of frost heave, the foundation was not deformed.

EGE №2 - Under the soil layer lies a layer of clastic-clay soils of eluvial-diluvial origin. Judging by the laboratory studies of the physical and mechanical properties of EGE №2, it cannot be recommended for construction because with excessive moisture, this soil can settle excessively and therefore pose a danger to the structures located on it.

EGE №3 - This type of soil (diluvial loam) can serve as a good foundation for buildings and structures due to sufficient indicators of strength and consistency.

EGE №4 - The described soils lie on parent rocky and semi-rocky rocks of the eastern, less steeply sloping part of the site. This type of soil can serve as a completely satisfactory foundation for buildings and structures due to sufficient indicators of strength and consistency.

EGE №5 - This horizon is most suitable as a natural basis for constructing high-rise buildings. However, the rocks of this group may have increased fissures or karstness and also time to be characterized by high strength in the sample.

From the results of laboratory studies of the physical and mechanical properties of soils, it can be seen that the moisture content of most soil samples reaches 22-24%, and increases with the depth of sampling, which is associated with greater water saturation of deeper horizons. In samples № 16 and № 17 from well № 4, the moisture content reaches 38 and 41%, respectively. Such high values are observed because they were taken at a depth below the groundwater level, which for well № 4 reaches 2 m. Water-saturated clays from these samples are in a plastic state. With excessive moisture, this soil can pose a danger to structures located on it.

One of the most important soil parameters that characterize the density of its structure (the smaller it is, the denser the soil, and therefore the better its construction properties) and is directly used in calculations is the porosity coefficient (Soils, 1997).

The porosity of all soils remains approximately within the same limits - 40-44%. However, sample №18, with a porosity of 50%, stands out from this set. Such high indicators may indicate possible subsidence properties of this soil. This negatively affects the choice of it as a basis for various types of construction.

Based on the results of the conducted investigations, an assessment was made of the stability of the fill soil mass along the predicted slip surface within the most weakened segment of the foundation soil, located between the excavated pit and the slope crest. The calculations were performed on a fragment of cross-section 3–3 (borehole No. 2) using the method of M. M. Maslov (Goptarova *et al.*, 2022).

Because of the results of previously carried out explorations in the area of the works, the predicted sliding plane can be a layer of the soil-vegetation layer, which lies obliquely on the clastic-clay eluvial-diluvial deposits under the layer of water-saturated bulk soils (DSTU ISO 15175:2005, 2005).

The calculation was carried out taking into account the combination of unfavorable factors that contribute to the occurrence of shear plastic deformations, namely: the seismic component directed toward the dip of the predicted slip surface; the hydrodynamic force of the filtration flow generated by the movement of perched groundwater, especially during periods of intense rainfall; the increase in soil density within the calculated mass due to prolonged infiltration of atmospheric precipitation and the saturation of all pore spaces with water; and the significant reduction in the strength parameters of the soil-vegetation layer within the predicted slip zone as a result of long-term moisture exposure.

Considering the specified factors, the calculated stability coefficient of the soil mass along the predicted slip surface is 0.89, which is less than 1. This indicates that shear forces exceed resisting forces, revealing the susceptibility of fill soils to plastic creep deformations. These deformations were locally manifested as solifluctional displacements, which were observed during the reconnaissance survey.

An increase in the intensity of predicted shear plastic deformations in periods of heavy rains, in the absence of engineering protection, can lead to the destruction of the edge of the slope and the landslide-flooding of the most weakened segment of the soil base (Poberezhna *et al*., 2022).
To prevent the development of erosive processes associated with washed-out of the site's surface by slope waters, it is advisable to prohibit the construction of ditches not equipped with protective paving on the slope in the direction of its inclination.

Conclusions

At the site of the construction of production well №914 – Pasichna it is advisable to provide:
- organized drainage of surface and slope waters from the site of works, which excludes the leakage of wastewater on cut and filled slopes;
- anti-slide measures related to the loading of the slope of the platform of the tower-winch block, built of bulk soil, blocks and boulders of rock;
- anti-erosion measures are related to preserving the stability of natural slopes during the laying of underground communications with the cutting of slopes to the structures designed at the work site;
- measures to carry out constant supervision of the condition of adjacent slopes and maintenance of a special regime that contributes to maintaining their stability.

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