DOI: https://doi.org/10.30836/igs.iies.2024.32

Streltsov A.

Institute of Geological Sciences of the National Academy of Sciences of Ukraine, Kyiv, Ukraine.
E-mail: streltsov.kiev.ua@gmail.com

ANALYSIS OF ENGINEERING AND GEOLOGICAL CONDITIONS AND THE ASSURANCE OF SLOPE STABILITY ON ONE OF THE DNIEPER SLOPE SECTION WITHIN THE PECHERSKY DISTRICT OF KYIV

The high investment attractiveness of real estate in the central part of Kyiv and the limited land fund for new construction cause great interest in the development of plots with complex engineering and geological conditions. Administratively, the studied territory is located between Ivan Mazepa Street, 1 and Parkova Road in the Pechersk District of Kyiv.

The studied territory is located at the intersection of the mixed forest zone and the forest-steppe zone of the Dnipro highland region. Orographically, the territory belongs to the Dnipro Highlands (Kyiv Plateau), dissected by systems of ravines and gullies. In terms of geomorphology, the research site is located in the edge of the Kyiv Loess Plateau and the slope edge to the Dnipro Valley [1]. The relief of the studied territory was formed as a result of the territory planning with bulk soils. In the north-eastern part, the site is bordered by a steep slope to the Dnipro River.

The geological structure of the area up to 30.0 m consists of this sediments [2]:

- (t H) – modern bulk soils, which are composed of sandy and dusty, dark gray, black, brownish-gray, hard and plastic loams, in places with an admixture of organic substances, with inclusions of construction debris up to 25% (broken bricks, rubble stones, wood, glass, scrap metal and others), with layers and lenses of hard-soft plastic loam 15%, capacity up to 10.4 m;
- (d, dz, b H) – a Holocene complex of deluvial, deluvial-slide and swampy soils, which is composed of sandy loams, dusty, from solid to fluid consistency, light rigid-plastic loams, in places with an admixture of organic substances and lenses of heavily peated soils. The capacity of the complex in some places is up to 11.8 m;
- (edv PIII-H) – eluvial-deluvial-eolian Late Neopleistocene-Holocene soils, which are represented by sandy loams, dusty, loess-like, subsidence, hard and plastic, loams light and heavy dusty, tightly plastic. The thickness of the layer is up to 12.1 m.
- (f,l-g PII) – a complex of Middle Neopleistocene rocks of fluvio-, limnoglacial, and glacial genesis, represented by dusty, dense sands, sandy loams, light and heavy loams, of various consistencies. The thickness of the layer reaches 9.0 m;
- (l PI-II) – a complex of Lower Neopleistocene rocks of limnic genesis represented by hard and semi-hard clays, light and heavy loams, with a total thickness of up to 9.7 m;
- (N_2čb) – deposits of the Pliocene Neogene system (red-brown clays), represented by light and heavy dusty, semi-hard and hard clays, up to 7.5 m thick;
- (N_{1-2}sg) – deposits of the Neogene system of the Lower Pliocene-Upper Miocene (variegated clays), which are composed of light and heavy, semi-hard and hard clays, up to 8.1 m thick;
- (N_1np) – deposits of the Neogene system of the Poltava series, which are represented by sandy, hard sandstones with weakly cemented sandstone lenses, with an open thickness of up to 6.3 m.

The hydrogeological conditions of the research area are characterized by the presence of one pressure-free mixed aquifer: the groundwater horizon in Holocene sediments and an aquifer complex in glacial and lacustrine sediments of the Neopleistocene [2,3].

Groundwater levels in the wells were established at depths of 7.7 m - 14.5 m. Within the upper flat part of the site, the absolute marks of the aquifer mirror vary from 179.59 m near the street. Mazepy up to 175.05 m on the edge of the slope. Along the slope, the levels change in the range of 175.00 m - 162.35 m. In some wells, an abnormally high level of underground water is noted - 175.00 m. This is connected with the formation of head water due to losses from water-bearing communications that pass along the edge of the slope.

A calculation of the slope stability in the natural and forecast states was performed according to profiles II-II', III-III' and IV-IV' (Fig. 1) to assess the slope state (stable, landslide-prone, landslide) from a geological point of view at the time of the investigations [2].

The work was performed in RocScience Slides 6 software. The Slides 6 program analyzes the sliding surfaces stability using methods of vertical compartments limit equilibrium. It makes it possible to analyze individual slip surfaces or to apply search methods to determine the critical slip surface for a given slope.

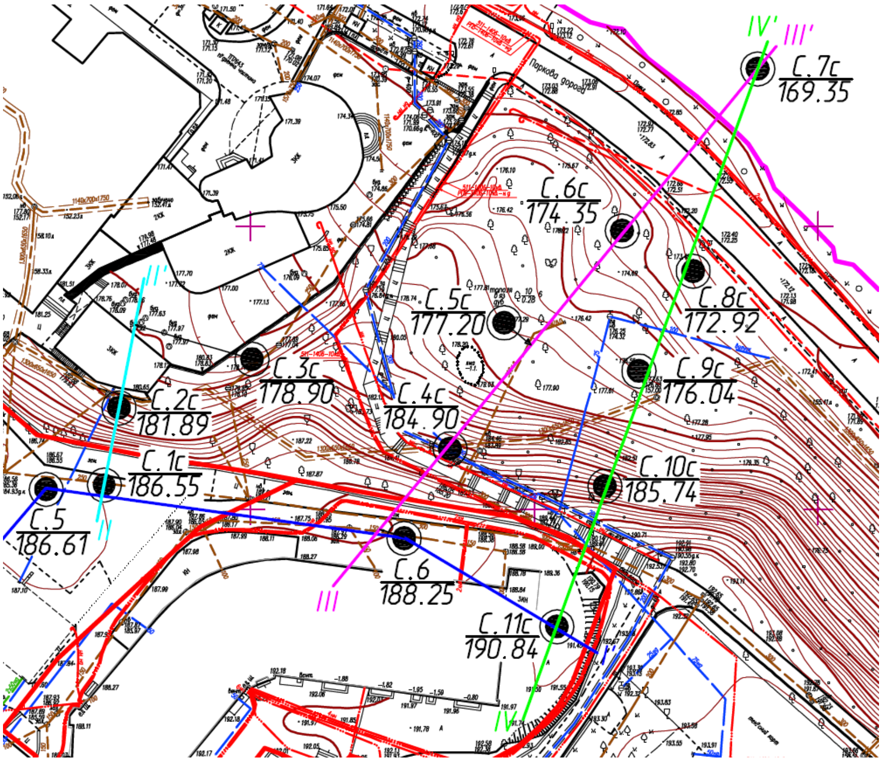

Fig. 1. Layout of calculation profiles

Calculations were carried out on a round-cylindrical sliding surface. The properties calculated characteristics of the selected engineering and geological elements are accepted at a confidence probability = 0.95. Walls and foundations of existing buildings are applied to profiles III-III' and IV-IV', taking into account the loads from them.

The forecast state was modeled taking into account a possible rise in the groundwater level by 1.5 m and wetting of the upper soil layers due to precipitation. According to table B.5 of DBN B.1.1-46:2017 [4], the normative factor of the stability margin under these conditions is 1.25.

Calculation results:

1. The slope along the II-II' profile is organized by several tiers of retaining walls, which were erected during the residential complex construction on the street. Hrushevskyi 11, therefore, together with the structure of the building, they perceive the main shear pressure from the slope. In its natural state, the probable sliding plane passes in the upper part of the slope on bulk soils, Kst (stability margin coefficient) is 1.41, which is greater than the normative value and indicates its stable condition. In the forecast state, Kst = 1.19. This value is below the norm, but the slope remains stable.

2. According to the III-III' profile in its natural state, the sliding plane originates behind the wall of the Komendatura building and passes through Lower Neopleistocene deposits of limnic genesis, which are lithologically represented by clays and loams. Kst = 1.47. The slope is in a stable state and is fully provided with a normative coefficient.

In the forecast state, the sliding curve shifts to the slope steepest part and then spreads to weak, heterogeneous deluvial-slide and bulk soils. Kst = 1.14, which is below the norm, and indicates that the slope is approaching the state of ultimate equilibrium.

3. According to the IV-IV' profile, in its natural state, the sliding surface passes over bulk soils and has Kst = 1.040. The obtained coefficient of the stability reserve is much smaller than the normative one, and indicates that this section of the slope is in a state of limit equilibrium.

When surveying this part of the slope, the presence of erosion processes is noted, which manifests itself in the form of planar and linear erosion, deep gullies, and the inclined growth of trees - "drunk forest", indicates the already existing landslide processes.

In the forecast state, the coefficient of stability reserve Kst =0.932. Under such conditions, there is a loss of stability and activation of shear processes within the slope.

The nature of the development of the most likely slip lines within the studied slope section indicates that under these conditions, the development of landslide processes will occur on bulk, deluvial-slide and limnic soils.

The specific topography of the site in the lower part of the III-III' profile indicates that in the past there was flooding of the soil mass of deluvial-slide soils.

Based on the results of slope stability calculations coefficients based on the calculated profiles obtained during searches, the following conclusions can be drawn:

1. The slope within the construction site is prone to landslides, and a separate part of it along the IV-IV' profile is landslide-prone;

2. The slope has a complex geomorphological structure, there are man-made sources of water saturation of the soil, which determines the differential moistening of the slope soil and different activity of surface erosion processes;

3. In the event of a part of the slope sliding on loose soils, it is possible to form a puncture of new sliding surfaces behind the wall of the existing building closest to the slope.

Based on the results of the work, technical decisions were substantiated in the design and construction of the anti-slide structure, which is a retaining wall on injection-molded piles with a monolithic reinforced concrete grid.

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