Geotechnical properties of gullying in Tomsk Oblast

A V Leonova, K M Lomakina, S A Dmitrieva, A V Baranova

National Research Tomsk Polytechnic University, 2, building 5, Lenin Avenue, Tomsk, tel. 3822-606-385,
[1]8-952-880-3608 avleonova@tpu.ru
[2] 8-952-887-6254 lokris@mail.ru
[3] 8-913-100-1005 dmitrieva_sa93@mail.ru
[4] 8-923-402-10-54 baranskikh@yandex.ru

Abstract. The article deals with causes, conditions and factors of gullying in Tomsk Oblast, the case of site Grodnenskaya. A nuclear-power station was planned to be constructed in Closed Administrative Territorial Unit Seversk, which led to geotechnical investigation of the area to study the geological processes developing there. The investigation included reconnaissance traverse of the area, geological and geomorphic descriptions, and sampling. The area and percentage of the territory affected by the geological processes were estimated. As a result, it was proved that the geological processes of the area are conditioned by surface water activity leading to gullying and river erosion, and by both ground water and surface water activity resulting in bog formation. It appears that gullying is caused not only by natural factors but also by technogenic ones.

1. Introduction

Geological processes developing in any areas are unfavorable factor that impedes construction work, destroys buildings and facilities and can lead to economic losses and environmental damage. To reduce the possible risks, it is necessary to provide a valid prediction of hazardous geological processes development, which is impossible without understanding the causes and factors of the process.

A nuclear-power station was planned to be constructed in Closed Administrative Territorial Unit Seversk, Tomsk Oblast. It caused a geotechnical investigation to be conducted on the site, which included the study of geological processes.

2. Materials and Methods

To study geotechnical conditions of the site, the area was traversed, samples were taken, and the geology and geomorphology of the area were described. The area and percentage of the territory affected by the geological processes were studied and estimated. The dynamics of the processes was studied by calculating the number and length increment of active and newly developed processes. Besides, laboratory testing was conducted to obtain the information on physical properties of the soils and rocks that build up the studied area [1].

3. Results and Discussion

The investigation of the site allows us to make the conclusion that there are two genetic groups of the processes conditioned by the natural factors:

- Processes trigged by geological activity of surface water – gullying and river erosion (Grodnenskaya site);
- Processes trigged by surface water and groundwater activity – bog formation (Orlovskaya site).

These processes are known to depend on climate features (high moisture or excessive moisture is necessary), surface topography (flat areas and sink-holes for water accumulation and bog formation, and slopes for gully formation), specific properties of superficial deposits (loose, unconsolidated rocks), groundwater flows and anthropogenic activity.

Gullying is the most developed geological process on Grodnenskaya site, which occupies almost 40% of the site [2] making the areas unsuitable for construction (fig.1).

There are a lot of branches and ravine tributaries in the gully sides, which form a developed gully network limited to the slopes of interfluve area Mostovka-Chernaya.

Figure 1. The gully on the studied site.

The gully network can be classified as highly eroded [3]. A developed gully network with both dry and wet gullies spreads from the top of the site down toward the river valleys. Most of the gullies are grass-covered and forested; however, there are rare cracks and failures of the sides, which means that the erosion still continues.

Gully formation and expansion is known to start from the top with a flow forming a narrow rill several meters wide. As long as the flow transports more and more soil particles, the crack develops into a ravine several dozens of meters wide. The depth of the gully depends on its topography and a base level of erosion.

The gullies of the studied area are of different size: from 2 to 43 m wide, with 0.5-7.0 m deep. They are at different stages of development: from water galls and developing gullies to grass-covered and forested ravines. The length of the gully network is 1.5 km and more. The side slopes are usually covered with grass and subdued. The longitudinal section has the form of a smooth curve. The cross-section is of U-type. The slopes of gullies and ravines are covered with birch, aspen, abies, and small spruce (up to 40 cm high). There are a lot of windthrown trees. The sides are covered with thick grass: sedge, horsetail, fern, and etc. There occur small hills of sedge 7 cm high and of a diameter up to 25 cm, they are covered with moss. The side slopes are prone to slumping, cracks and paps (fig. 2). As a rule, a temporal flow cuts the gully bottom. The observed fresh cut, 40-105 cm wide and 15-30 cm deep, continues to develop the gully. Sand and sand clay are exposed in the cut (fig. 3).

The basic factors contributing to the gullying on the site are as follows:

- Soil properties: the soil consists of silt loam, sand clay and sand.

- Temporal water flows that make gullying possible even with gentle slope of the area.
- Man-made factors: road construction and operation, turf cutting on the areas with gentle slope, which leads to sink-holes development.

Figure 2. Slumping.

Figure 3. Sand clay in the gully side.

Obviously the processes have been taking place for several decades, which is proved by almost unnoticed ravines in the forest to the right of the road to Krasniy Yar along the abandoned roads. It should be noted that the active gullies occur in flat areas with gentle slope. Gully formation in such areas is conditioned by man-made factors such as plant destruction and deforestation, destruction of rock integrity. Gully formation on the area is an intensified process, and it can be hardly expected to stabilize soon due to natural causes.

Having studied the conditions of gully development, we cannot confidently determine the nature of gully network formation on the studied site. This geological process may be conditioned by modern tectonic movements resulting in change of the local base level. Temporal water flows intensify erosion moving to the base-level. Having done it, they stabilize for a while. This supposition is proved by the forms of erosion – the edges and sides of the gullies are covered with vegetation, while the bottoms are eroded by fresh cuts.

4. Conclusions

To come to the final conclusion on the nature of this geological process, the site needs further observation and study.

However, it can be asserted that the unfavorable geological processes are strongly developed on the area. The processes are conditioned by both natural and man-made factors. The processes being in progress, it is necessary to take protective and preventive measures in case of the area development.

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