Geotechnical problems in urban terrains

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Abstract: Rapid growth of civil engineering leads to the significant deterioration of geological ground conditions. This process is mostly obvious for the strand terrains of the river valleys. Stratification of the valley terrains is characterized by diluvial and alluvial deposits. The existing situation is complicated by the development of a network of small river valleys, ravines and other relief features. This is influenced not only by natural processes but also under the processes activated by human factors.

Such processes are: landslides (725 cities), earthquakes (103), avalanches and earthflows (14), ravine erosion (442), dolines (301) elutriation (958), loess slumping (563). During the last 15 years in urbanized territories these areas increased up to 50-60% due to the maintenance and preventive works refusal.

Groundwater uplift has occurred because of the change in relief by grading and levelling, but the major causes are leakages from the underground pipes (water supply, sewage, drainage, heat supply, etc). For a large city the volume of leaks is estimated up to 10000 m3 per day. For the majority of investigated sites the phreatic line's uplift is 8-10m and groundwater level nowadays is not deeper then 2-4 m from the ground level.

Another problem to consider is the soil's elutriation. It is determined by: a) old mines; b) pipes laid in insufficiently compacted soils; c) leakages from these pipes.

The significant factor for risk assessment is presence of intensively fissured zones. It is problematic to determine exactly the depressed areas in diluvial and alluvial deposits. It is necessary to explore the tectonic structure of the bedrock and then to confront it to the geological conditions.

Résumé: Dans l'article proposé les auteurs analysent la situation géotechnique et les perspectives de l'utilisation rationnelle des territoires urbains. En réalisant le monitoring géotechnique au cours des observations de plusieurs années, les auteurs amènent les facteurs principaux donnant l'influence essentielle sur la situation géoécologique, la condition de l'exploitation des bâtiments et les des constructions et proposent les directions de l'utilisation perspective des terrains urbains.

Keywords: diluvial, allgeotechnical vial, monitoring, urban territories, groundwater uplift

INTRODUCTION

Cities are growing larger even when there still are some territorial resources inside of the existing borders of Russia. This is due to the wish to assimilate new territories that are the most important for municipal engineering, and to keep in reserve the inappropriate areas, which require special engineering solutions and greater capital outlays. The town-planning usually didn’t envisage the assimilation of improper acres. The city passed them around. Inside of the city large unoccupied spaces remained, while the city limits expanded by assimilating the periphery.

The widening of the cities upsets the geological ambience balance by industrial influence, and results in transformations, which are mostly unfavorable for the land maintenance, first of all because of the disturbing of the groundwater’s balance, which is the dominant dynamic factor.

This situation is more evident in the cities standing on floodplain terrace of large rivers having typical foliation of alluvial-dilluvial sediments. The soil morphology of such territories is complicated by a network of little river valleys, gullies and ravines. These territories are modified not only by the exogenous (surface) processes but also because of the processes activated by anthropogenic factor.

Such factors include: landslide and landslip (725 cities) (Fig. 1), earthquakes (103), avalanches and mudflows (14), ravine erosion (442), karst (301), suffosion (958) (Fig.2), loess slumping (563) *(Osipov, 2001*).

Figure 1. Perm, 2005

Figure 2. Perm, 2003

During the last 15 years the total area affected by these processes within the urbanized territory increased by 50-60%.

In many respects it happened because of nearly utter cessation, in the 1990s, in most cities of Russia, of the preventive measures warning the dangerous tendencies development by means of engineering protection.

THE BASIC CLASSIFICATION FACTORS AND OBJECTS

Rising groundwater levels (underflooding) are caused by changes in atmospheric water surface flow and groundwater migration. But the considerable part of the cases occurs because of the water pipeline leakages. In a big city the volume of such leakages can reach over 10000 m^3 in a day. In many cities the groundwater level has risen 8-10 meters on average for the last forty years, and lies at the moment at the depth of 2-4 m from the surface (Fig. 3).

The transformation of engineering-geological characteristics in combination with the contamination of underground and surface hydrosphere creates geological\ hazards to existing building structures and pipelines.

It is considered that the natural groundwater's regime mostly is of stable, permanent kind and is defined by cosmogeneous, climatic and endogenous factors, and also that groundwater spreading in plan on territories commensurable with industrial structures is relatively proportional.

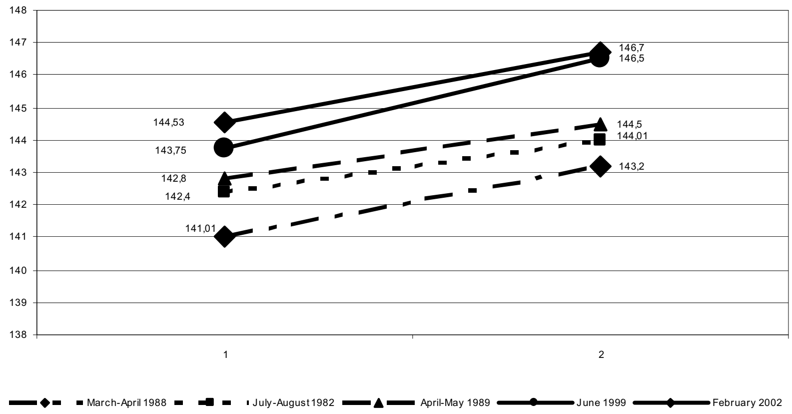

Figure 3. The dynamics of the groundwater level increasing in course of industrial underflooding. (Sverdlovskiy region, Perm)

The general and local rise of groundwater level is now a serious problem for majority of large cities located on floodplain terraces.

In Russia the underflooded area stretches for about 800 thousand hectare of urban zone. The underflooding was noted in 960 (88%) out of 1092 cities, including Moscow, Saint Petersburg, Novosibirsk, Omsk, Rostov-on-Don, Tomsk, Khabarovsk, Novgorod, Yaroslavl, Kazan. The damage caused by underflooding of urban territory (depending on measure of the density of permanent structures, presence of historic and architectural monuments, branching of underground infrastructure) ranges from \$15,000 to \$200,000/ha.

The perched water phenomenon is widespread in large cities. Basically it is conditioned by the difference between filtration characteristic of the higher part of the cut and feeding of underground water. The area of perched water "patches" can be of ten meters up to several tens hectares. The man-caused perched water phenomenon appears in urban and industrial zones, characterized by the formation of a "dome", which then spreads into the surrounding territory. Gradually the man-caused industrial perched water joins to pore groundwater irrigating the whole overburden stratum.

During underflooding the soil can acquire new features in composition and characteristics, changes the structure, mass, density, toughness, permeability etc. In general the following processes can occur: dissolution of solid-phase soil components in acids and alkalis solutions; hydration and hydrolysis of natural and artificial silicates and aluminum silicates and concomitant processes (*Voronkevich, 2000)*.

When the sulfuric water influences clay soils, the intensity and the sequence of on-going processes depends on the soils composition. The soils density and toughness decrease, while filtering velocity increases. The clay minerals are broken down. The complex of these processes favors the considerable deterioration of toughness and deformative soil characteristic.

Alkaline hydrolysis of clay minerals and soils develops when there is underflooding by alkaline water. The intensity and directivity of the processes, as well as the nature and degree of their transformations under alkaline hydrolysis depend on the alkali concentration. The set of the processes occuring in the systems promotes the dispersion of clay particle aggregates, increasing of soil turgescence by 2-3 times in comparison with the value of this factor in water ambience, reduction of their density and toughness.

The underflooding process of urban territory can be divided into two stages: local underflooding and zonal underflooding. The groundwater expansion from different sources in the initial period is localised and of dome form. It then comes beyond the limits of the geodynamic zones and forms the underflooded circles on larger area.

A striking example of local underflooding is the development of this process in base of dwelling houses of first mass series. This phenomenon is practically noted in a majority of dwelling buildings located in Industrial, Sverdlovskiy and Motovilihinskiy regions of the city of Perm. Investigations carried between 1961 and 1967 have shown that the greatest part of territory of these regions lies on 6-12m of dusty-clay soils of stuff and semisolid consistence. Intense leakages of water pipeline connections has led to flooding of subbasements and technical cellars. The soils in the buildings basement have acquired soft and fluid consistence. This has brought about a great and, what's the most important, irregular reduction of toughness and deformative features: module of soil deformation decreased by 35-40%, and specific adhesion by 40-60% (The Table 1.).

Table 1. Variation of soil features in an underflooded zone**.**

	γ, (kN/m^3)	**c, (kPa)**	**φ, (°)**	**E, Mpa**
Beyond the underflooded zone	19,1…19,3	26…28	19…21	8…10
Within the underflooded zone:				
Building outline	18,3…18,6	14…16	13…15	5…6
Pipeline entry	17,1…17,4	11…13	11…13	3…5

As the basement dampness increases the working soil compressive resistance reduces by around 15-25%, and as a result in several points under the building this value grows less than the base pressure. This causes both an intensive development of absolute outflanking and the further increasing of their unevenness on spot of the building. A serious inequality of base outflanking brings about progressive structural damage to the buildings.

Depending on the concrete type, the reliability problem has specific features that obstruct the creating of some general manual on the methods of evaluation and ensuring the no-failure operation. The subject of inquiry implies, in strictly specialized terms, a building project that can be presented as an assemblage of buildings, separate buildings and structures, constructions, component, material or soil. The megasystem comprises the range of buildings or structures (under construction, exploited or their combinations) and engineering-geological conditions within this megasystem limits. For megasystem reliability evaluation it is required to take into consideration the mutual influence of its components. Ignoring these considerations during the early stages of investigation, design and construction quite often results in emergencies. The geology presents a most significant factor for megasystem reliability determination.

The underflooding factors can be divided into natural and man-caused. Among the natural factors the main are precipitation (rain and melting water) seepage, relief and geological-lithologic construction. One cannot avoid the precipitation seepage but it can be considerably reduced by means of organization of the surface runoff. The soils constituting the upper part of section on the city territory are mostly of the heavy mineral composition (clays, loams) with low filtration characteristic that causes the backing of the groundwater flow from overlying area and promotes the underflooding development. The casing in tubes of the rivers Permyanka and Daniliha, flowing in the city center, has played the essential role in changing of the atmospheric water surface runoff. The channels of these rivers served as a natural urban watershed.

One of main industrial factors is water pipelines leakage. There are numerous reasons of the leakage – such the poor quality of pipelines used in construction; poor building, construction and repair workmanship; late realization of current and complete repairs. It is necessary to consider also the increased water consumption of the city, which is typical for large settlements. Of course, consumption rises, the amount of the leakage losses of water increases. The effect of these factors is aggravated when the groundwater level is rising. The excessive ground humidity provokes the intensive corrosion of the metallic pipes and their earlier lay-up. In the presence of groundwater aggressive to concrete the same occurs to concrete and asbestos-cement pipes. The analysis of water consumption and drainage, of shaping mode of the groundwaters domes, of changing dynamics of underground water chemistry shows that in several areas the leakage attains 40% of water consumption value.

There is a certain influence upon underflooding exerted by the regulation of the small rivers of the city. Following the construction of Kamskaya hydro power plant and filling up of Kama reservoir, the water level in Kama river increased and created the backing to the groundwater flow. This has caused the redistribution of groundwater levels on the whole reservoir coast territory.

CONCLUSIONS

The estimation and forecasting of the safety of underflooded territories must be based on the data of areal and volumetric structural-geodynamic texture and stage of the massif. Such data can be obtained without well drilling by means of geological-geophysical investigation.

The geological ambience in the cities with developed industry is subjected to an intensive industrial influence, that quite often brings about development of the processes and phenomena, which negatively affect engineering structures. In view of the requirement to consider many factors it constitutes a difficult problem to work out methods to predict the beginning and development of negative processes. On the whole, the methods for forecasting urban engineering-geological conditions change have not been worked out. In this connection appears the necessity to estimate the change of the geological ambience state, to work out and prove actions on prevention of the negative processes development or on protection of the buildings, as well as to estimate this actions efficiency that is to say geological ambience monitoring.

For optimum town-planning development in Perm there is an objective necessity of a phased introduction of hydro-litho monitoring elements, which aims to organize rational subsoil use and development of actions for conservancy of geological ambience of the city.

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