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GEOTECHNICAL MONITORING DURING CONSTRUCTION IN DIFFICULT SOIL CONDITIONS

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One of the common and at the same time most difficult problems that developers may face is unstable soil layer at the base of a future building. This paper describes problems of construction on weak, subsidence and heaving soils in engineering and geological conditions of Kursk city. Real problem of construction property safety is shown with the example of one of the demanding geomorphological and lithological conditions of urban areas. The paper offers a description of geologic and hydrogeological features of the slope rock mass in the right bank of the Tuskar river. Groundwater level lies at 8.7 m. depth. It is possible to predict an increase in the level of groundwater in building maintenance because this area is potentially flooded. Various engineering and geological processes and such phenomena as ground subsidence, karst, suffosia, landslides, flooding, etc., can also be found in the studied territory Initially an insufficient engineering-geomorphological, hydrogeological, ecological and engineering-geological study of hazardous areas in the city of Kursk have led to its problematic development, which illustrates the situation with residential real estate in the studied territory. To predict dangerous engineering-geological processes and ensure the reliability of the construction fund, specific proposals have been developed for the organization of a geotechnical monitoring system based on the optimal integration of geomorphological, geodesic, engineering-geological, hydrogeological and environmental construction methods in complex engineering-geological conditions.

Key words: real estate, soils, flooding, deformations, landslide, subsidence, suffusion, safety of building fund

INTRODUCTION

Despite their relevance in modern educational and scientific literature the attention paid to construction issues in specific soil conditions is insufficient. Construction problems on weak, subsidence, heaving soils in complex geomorphological conditions are due to the uncertainty of external influences in time, place and value. Traditional methods of construction under specific soil conditions are mainly reduced to methods of soil strengthening, ignoring weak soil (its cutting or using piles-stands) or overcoming its negative properties by means of foundation arrangement with minimum costs. We will show this problem on the example of urban development territory of Kursk, which has rather difficult geomorphology and hydrogeology, as well as the diversity of soil base.

THE PURPOSE OF THE STUDY

The purpose of the present work is to develop an optimal approach to the study and characterization of the state of ground, natural and man-made conditions that can be formed during the process of urbanization. This approach is necessary to ensure the security of the real estate fund in a particular territory. The authors propose an original system of geotechnical monitoring based on the integration of geomorphological, geodesic, engineering-geological, hydrogeological and ecological methods of construction on weak, subsident, heaving soils in the engineering-geological conditions of Kursk city.

STUDY MATERIAL AND METHODOLOGY

The research uses methods of natural-historical analysis, methods and techniques of geomorphological, geodesic, engineering-geological, hydrogeological and environmental surveys for the construction, operation and reconstruction of buildings and engineering structures. The research is based on numerous stock and published materials of industrial and scientific organizations of Kursk and the Kursk region, as well as field materials of the authors in the study area.

RESULTS

It is well known that geotechnical monitoring is regulated by relevant regulatory documents. According to operating regulations [1,2], observations should be carried out on underground and ground structures both objects under construction and of objects under operation or reconstruction, as well as on soil massifs with groundwater of their watering, lying in the base and around construction object and real estate. So, the main task of geotechnical monitoring is not only the establishment of engineering and geological conditions at a time, but also the prediction of their possible changes in time and space. This is complemented by the development of necessary measures to ensure the safety of real estate near the object under investigation.

The city of Kursk is located on the south-west and south macroslope of Central Russian Upland. The main fea-

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tures of its relief and geological structure are significant depth of dissection, an abundance of different erosion forms, Late Mesozoic chalks and marls under relatively low-power Quaternary (mainly alluvium) and Neogene (eluvium) deposits. There are four types of landscape complexes according to the relief, relief-forming rocks and soil covering, depth of groundwater and microclimate (Fig. 1). They are floodplain, floodplain-terraced, prone, watershed-upland [3,4].

Ravine system originated from natural landscapes and actively developing in the process of urbanization is quite common on the territory of Kursk. Urban ravine areas are a single indivisible system that tends to intensify hazardous geological processes and increase boundaries. Therefore, urban planning should be carried out according to ravine system, and not in particular areas that are attractive for investment. But today, almost all recommendations for the development of urban ravine territories are usually recycling (development, transport communications, recreation) and destructive methods (backfilling, waste disposal).

The complex geomorphological conditions of the studied territory predetermined the wide development of various engineering-geological processes and phenomena, such as subsidence, karst, suffusion, landslides, floods, etc. But initially, insufficient engineering-geomorphological and engineering-geological study of hazardous areas in Kursk has already led to reckless and problematic development of it [5, 6]. At the same time, numerous modern studies have shown that it is frivolous, and often simply risky, to ignore such processes [6, 7].

So, in 2020, students of Construction and Architecture Faculty of Southwest State University made geodesic observations of deviations from walls vertical of some buildings in the city of Kursk (located on Mirnaya St. and K. Zelenko St.) during their academic geodesic practice. It was done under the leadership of Associate Professor Vladimir Kapustin. Observations were made by inclined projection at two positions of vertical circle of theodolite [8, 9]. As a result, a deviation of the top of one 9-story residential building from the vertical relative to the basement level is 250 mm, the other residential building is 120 mm.

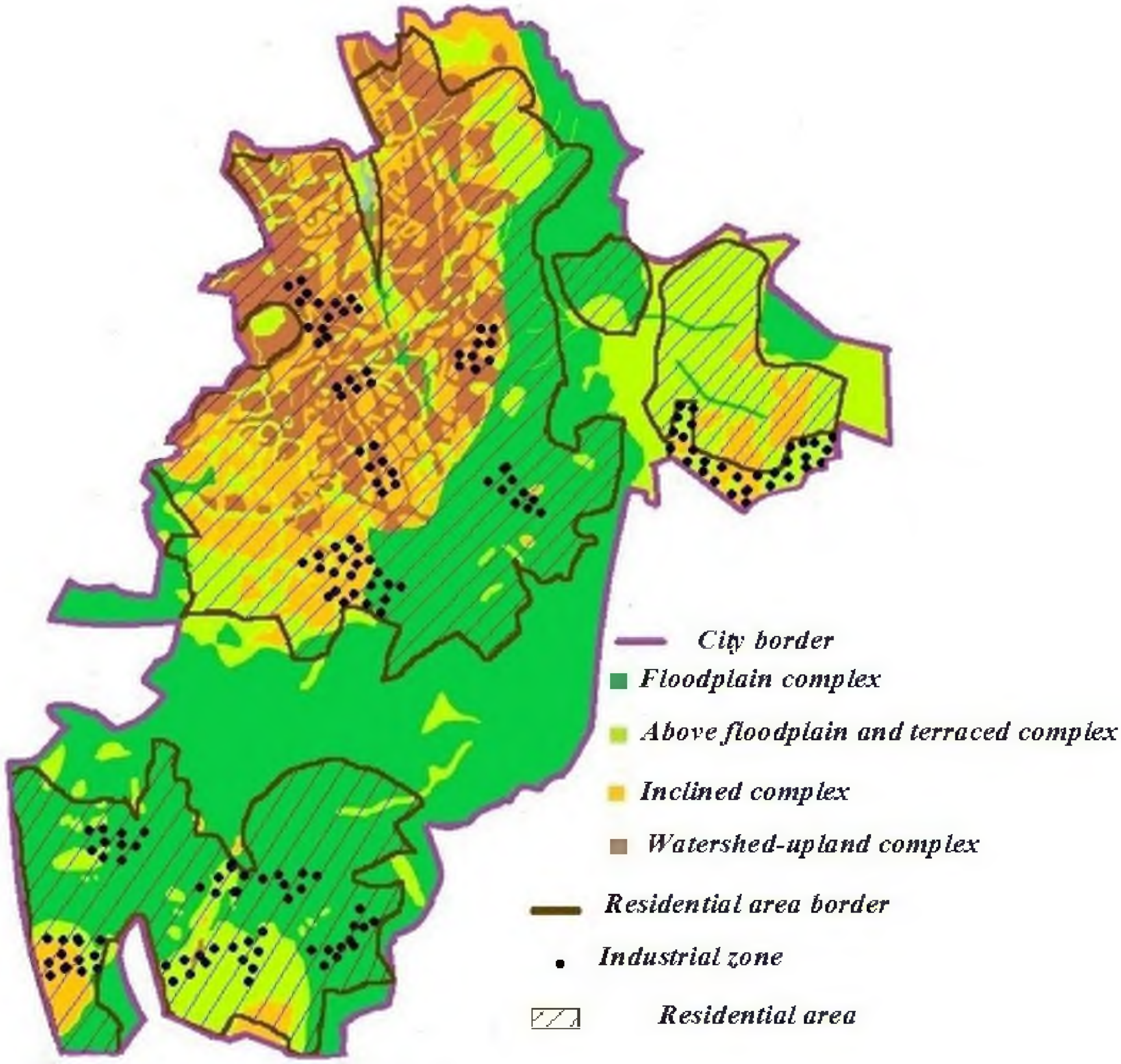

Figure 1: Diagram of landscape and functional zones of Kursk

At the same time, the tilt of the building is directed down the slope towards the local basis of erosion-the valley of the Tuskar River (Fig. 2, 3). This situation requires urgent clarification of its causes.

Geomorphologically, the site is in the middle part of the slope of the watershed, with a general slope eastward towards the valley of the river Tuscar. The relief of this area is uneven, absolute elevations of the earth's surface are from 215-220 m abs.

The studied territory is distribution zone of modern (Q_{IV}), paleogene (₽) and upper cretaceous (K_2) deposits. Upper Cretaceous deposits are represented by weathered and dense marls, clay thrusts, partially crushed; paleogene deposits are represented by clays. Modern deposits (the zone of active interaction of the building with the ground base) are represented by middle-upper Quaternary deposits (Figure 4). Aeolian-deluvial loams and sandy loams of various consistencies are combined into a single complex with cover formations. The cover formations are represented by loess-like loams (less often loams) of solid and semi-solid consistency. Loess-like loams have subsidence properties, the thickness of the subsidence is from 4-7 meters.

Figure 2: The size of the tilt: a) a residential building on Zelenko street (Kursk); b) a residential building on Mirnaya street (Kursk)

Figure 3: Location of studied real estate properties (deviation from top vertical, 08.07.2020)

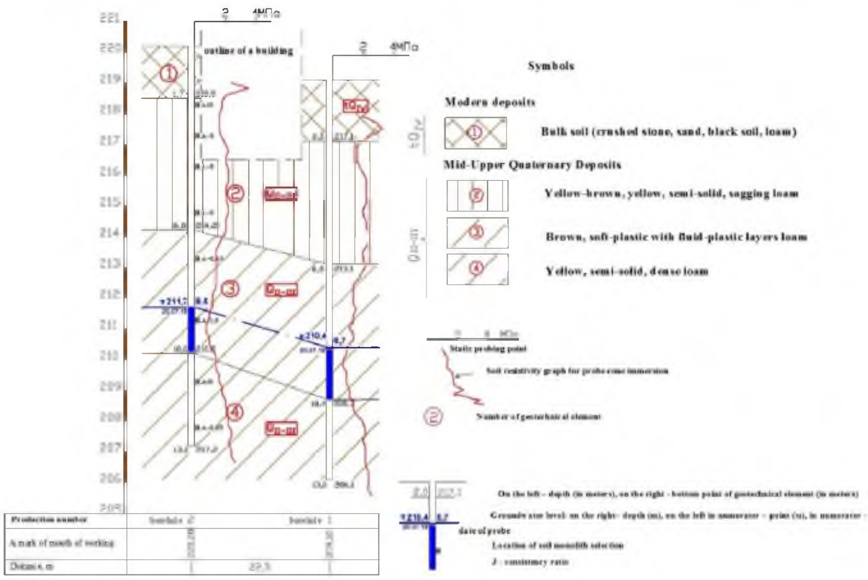

Figure 4: Conditions of cast-genetic varieties of soils of the studied area

According to the Code of Rules 28.13330.2012 "Protection against corrosion of construction", studied soils on chloride content (54-91 mg/kg) and sulphate content (323-478 mg/kg) are non-aggressive with respect to concrete grade W4 on portland cement and reinforced concrete structures. They have average corrosion activity to lead and high aluminum cable shells. It is necessary to consider an average corrosive activity of the soil in relation to carbon steel of underground metal structures on the recommendation of TISIZ LLC (Kursk).

Groundwater was found at a depth of 8.7 m. but it is predicted that the level of the groundwater level will grow because the area of the study is considered to be potentially flooded. The causes and forecast estimates of floods are discussed in detail in the article [10]. Pile foundations of residential buildings in the study area are located in the flood zone. From the practice of construction and operation of engineering structures and buildings, it follows that an increase in the ground water level leads to "flooding" of basic structures. Loess soils get subsidence, loose sands are compacted, chemical suffusion of some minerals (gypsum, etc.) can develop, the formation of local dips as a result of the collapse of the arches of karst cavities in limestone, etc.

According to the INTERSTATE STANDARD 25100-2011 “Soils. Classification.” soils are medium and swellable by the degree of frost.

The process of swelling and shrinkage of the soil base is that moisture entering the soil is adsorbed by clay particles surface, forming hydrate shells. They expand, causing an increase in the volume of soil with the initial relatively close arrangement of particles under the action of hydrate shells. Part of the water penetrates the crystals of clay minerals also leading to an increase in the volume of soil. There is volume deformation when humidity of swellable soils decreases [11].

Numerous field observations in our country and abroad of various buildings and structures deformations made it possible to state that swelling and shrinkage of soils occur as a result of [12,13]:

- man-made soaking of soils (leaks from water-carrying utilities, moisture condensation under covered areas);
- seasonal change of humidity of swelling soils under the influence of climatic factors;
- change of moisture evaporation conditions after development and asphalting of the territory.

As for the studied area, the causes of base soil swelling phenomenon are:

- rise of groundwater level and soaking of soils;
- humidification of soils with surface water with increased acidity;
- accumulation of moisture in the area limited in depth under the structure as a result of violation of natural evaporation conditions from the shielding of the territory (dense urban development);
- influence of water-heat mode change in upper part of aeration zone, which is the result of average temperature increase in city conditions.

It is likely that volumetric deformations in the soil mass of the studied slope section can lead to the movement of rocks which, of course, is facilitated by complex geomorphological conditions. This can happen by means of described processes and their moistening by surface and underground waters. A more accurate answer to these questions can be given by a complex of special geomorphologic, geodetic, engineering-geological and hydrogeological studies, environmental researches [14, 15].

In the central part of Kursk, landslides, due to the rather dense network of ravines and beams located here, are widespread on their slopes. More often, these are small-sized landslides, covering quaternary rocks of weathering zone, less often with the bedrock of the upper fractured zone. Volumes of landslide soil masses of such landslides usually do not exceed 10-15 m3. Unfortunately, no special detailed engineering-geological and hydrogeological studies were conducted in these territories. However, even multi-storey buildings are built here, as a rule, after creating the right size of a flat platform (berm), which can later be associated with significant risk [16, 17].

CONCLUSIONS

In order to monitor hazardous geological processes in the city of Kursk, it is proposed to deploy a special geodetic network, approximately from 10 points, on the study area where multistorey housing is planned. Near each of the geodetic points, observation wells should be equipped for monitoring ground water. In these wells, systematic observations of the underground water level, its chemical composition and temperature should be carried out. On the established observation network, it is necessary to organize systematic observations to determine the need to expand the geotechnical monitoring system. Conducting accurate geodetic observations on landslide-prone slopes should ensure the solution of the following main tasks: the study of the mechanism and dynamics of the landslide process, subsidence, suffusion and karst. Solving these problems is necessary to ensure the safety of the design, construction, reconstruction and operation of existing real estate objects.

Today improvement of theoretical provisions and methods, techniques, algorithms and technologies of studying landslide processes based on modeling changing in time of geological and geodetic (shifts, regularities of the movement, the field of deformations) parameters is up to date. In this regard, the results of monitoring in conjunction with geomorphologic, geodetic, engineering-geological, hydro geological and environmental studies will serve as the basis for the development of the necessary protective measures in the study area.

It is necessary to keep in mind a large number of land plots in the city of Kursk and other localities of the Kursk region with similar natural and man-made conditions.

Further improvement of the proposed approach to the organization of geotechnical monitoring, based on the optimal integration of geomorphologic, geodesic, engineering-geological, hydro geological and environmental methods in construction in complex engineering-geological conditions, will allow developing a methodological basis for its application in other difficult areas.

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