Performance of surveying to assess man-made risks in operation of industrial facilities by example of Volgograd agglomeration

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Abstract. The expediency of evaluation by geodetic methods of technogenic risk associated with the implementation of the technological process of production, and with various geophysical effects of the environment in the operation of industrial construction. The results of the analysis of the materials of long-term geodetic observations of the state of the largest energy enterprises of the Volgograd region – the Volga hydroelectric power station and heat electropower station-2, and also of metallurgy - Volzhsky pipe plant. Its enterprises have fundamentally different operating conditions, having different effects on the elements of the environment, and built in different engineering-geological conditions. Based on these results, the recommended composition of geodetic works and their optimal periodicity for industrial buildings and structures under different operating conditions is proposed. Also, the features of the rational implementation of geodetic observations and the state of individual parts of structures, such as crane tracks workshops of industrial enterprises.

1. Introduction

Currently, the issues of geo-environmental safety of economic objects are the most important in solving the problem of reducing the anthropogenic risk of urban space [1], including the operation of buildings and structures.

Industrial development areas are complex natural and technical systems with the inherent nature of each of them development, determined by the action of a significant number of factors. To ensure the safe operation of construction projects, an assessment of the impact of a set of external and internal factors grouped into stability criteria should be carried out periodically. Achieving the safe operation of an industrial facility is possible only with the systematic implementation of measures to increase the stability of the criteria approaching the minimum technical level of safety [2].

Technogenic factors that reduce the stability of the state of buildings, structures and technological equipment are: vibration impact of machines and mechanisms working in them, as well as heavy vehicles moving in close proximity, intensive operation of underground space, especially near the Foundation, changes in the nature of endogenous and exogenous processes, etc.

2. Methods of evaluation of geoeconomic safety of industrial facilities

In the direction of assessing the geoeconomic safety of industrial facilities, the main scientific developments were carried out to assess the complexity of engineering - geological conditions,
including tectonic and landslide hazard [3]. It was found that the allocation of one or several main factors that cause the development of negative processes is often not possible [4]. Multi-factor analysis of engineering-geoecological data is required, which should be carried out using GIS methods [5-7].

At the same time, the manifestation of one of the geoecological problems of urbanized territory causes the development of others. So, breakthroughs of water supply and sanitation systems lead to waterlogging of soils and reduce their strength characteristics. Swollen soils become weakly permeable, cause the development of processes of flooding and deformation of buildings and structures [8-10].

An integral method for assessing the intensity of the processes causing deformation of buildings and structures is the study and analysis of its results based on the materials of geodetic observations.

Purpose of geodetic observations carried out to assess the condition of structures and stability of the installed technological equipment is to identify of character and the magnitudes of deformations, the determination of the resistance of the mentioned objects. At unique and large critical facilities, observations begin immediately upon completion of the first phase of construction and continue throughout their construction and operation. Observations are carried out in accordance with the project drawn up on the basis of existing building codes and regulations. It should include: terms of reference for the production of the robot and the necessary information about the structure, natural conditions and mode of its operation, the scheme of placement of deep reference points and sedimentary marks, especially the performance of observations, the requirements of the necessary accuracy of geodetic measurements [11] indented.

3. Results and Discussion

To identify the optimal periodicity of geodetic observations of precipitation and displacement of large industrial buildings, structures and technological equipment and to clarify the standard methods of work, we have carried out studies at the largest enterprises of the Volgograd agglomeration: energy – Volga hydroelectric power station and heat electropower station-2 and metallurgy – Volga pipe plant.

The Volga hydroelectric power station includes a building of station power house, edifice facilities for trash deterrence, spillway dam and ground dam. All of them are undergo by intensive influences, both internal and external technogenic factors. Tectonic faults crossing the bases of the Volga hydroelectric dams are a complicating factor in maintaining the stability of the structures. To obtain objective information about the magnitudes of the precipitation of different structures were created by high-altitude network of grouped in the bushes of the deep frames and sedimentary models. Repper bushes were built on the right and left indigenous banks of the river. Volga and the adjacent plot of the Volga-Akhtuba floodplain. The bases of the points of reppers were installed on the rocky basis at a depth of 25.8 to 64 m.

It was assumed that this penetration of benchmarks will provide the necessary permanence of their marks, but in the process of long-term observations was detected a decreasing trend of the excess between the bushes right and left banks as a result of differences in the intensity and direction of geodynamic processes of the earth's crust on different sides of deep faults. To exclude the influence of numerical intensities of these processes on the results of the calculated values of the brands of structures, the head of geodetic works at Volga hydroelectric power station A V Klimenko, since 1986, began to introduce compensating corrections in the results of the calculated sedimentary marks.

In subsequent years, there were changes in the exceedances between the deep marks of reppers in the their groups which, having a certain tendency of General orientation, varied greatly over the years, sometimes even taking the opposite sign. According to our assessment, the cause of changes was the impact of anthropogenic factors. Near the groups of rappers on the right Bank of the Volga river was built and put into operation the building of a new workshop of the tractor plant. The territory of the groups of rappers on the left Bank was used for irrigation gardening and vegetable growing. Reference points on the Volga-Akhtuba floodplain after the construction of a two-storey brick office of the hydroelectric power station was turn out inside the building. Based on the fact that the intensive anthropogenic impact on the components of geosystems can extend to a depth of tens of meters, the
most likely is that a systematic sufficiently intense anthropogenic impact was the main cause of instability of deep reference reppers points.

It follows from the above that at the Volga hydroelectric power station, which has a large length of the pressure front and is characterized by difficult conditions for geodetic works, even the presence of a network of deep reference points for long periods of time between the measurement complexes can not guarantee the possibility of determining the precipitation with the accuracy required by regulatory documents, due to the large influence of external (independent of the contractor) factors. Only an annual sequential analysis of the observations will make it possible to identify systematic errors caused by the influence of external conditions (geodynamic processes, differences in temperature and humidity of heavy traffic, etc.) and to establish the reasons for obtaining conflicting data, as well as to determine the need for adjustments and provide reasonable conclusions and proposals.

To similar conclusions came the researchers of the geodetic division of the Institute "HYDROPROJECT RAO EES of Russia" [12]. Rational are the expediency proposed by them to establish a permanent link between the lower and upper parts of the sedimentary marks of the Volga hydroelectric power station building and some other recommendations and clarifications of the method of geodetic works. However, their proposed approach of deep groups of repper to dams near areas with high traffic intensity of rail and multi-ton road freight transport, i.e. near the dams. in places of strong anthropogenic impact, can’t be considered rational.

To ensure quality monitoring of the state of hydroelectric power plants processing and analysis of the results of geodetic works should be carried out over a long period as possible by a permanent group of independent (not in the state of hydroelectric power plants) highly qualified specialists. As an example of the rationality of this proposal, we can cite the fact that only on the basis of the analysis of long-term data (38 years) we have established differences in the nature of compaction of alluvial soils of earthen dams in areas with the presence and absence of tree plantations. Compaction and subsidence of soils anchored by tree roots, is more even (at first slower in the subsequent more intense), which reduces the risk of ground cracking. The largest thermal power plant heat electropower station-2 is located on a wide terrace of the flat sea plain, composed of a powerful layer of deposits of khvalyn chocolate clays [13]. Their characteristic feature is swelling when moistened, swelling when wet rock is frozen, compaction when it dries and under the influence of heavy load. The result of these processes can be deformations of buildings and structures.

Geodetic works are carried out with the use of 4 deep reference points and sedimentary marks installed on the foundations. In the initial period of operation of buildings and structures of heat electropower station geodetic observations and assessment of the intensity of precipitation processes were carried out annually, then the transition to periodic observations, continuing to the present time.

Geodetic works to determine the vertical movements of the foundations of buildings in accordance with the requirements of normative documentation [14-17] performed geometric leveling class II: first, between the deep reference points, the results of which evaluated the stability of their condition, then laid the moves to determine the values of displacement of deformation marks.

The analysis of changes in the marks of deformation marks was performed over a 26-year period. It was found that during the first thirteen years, the sediment values of some buildings and structures of the heat electropower station, located in areas with strong fluctuations in soil moisture gradually increased, changing in different parts within 22-67 mm.at the same time, one of the walls of the building of chemical water treatment on the contrary rose by 52 mm. as a result, there were some deformations of construction objects, which is quite characteristic of such conditions [18,19]. The main part of the sediment structures was 20-30 mm. Therefore, in the first 5 years of operation of buildings and structures of the heat electropower station it is advisable to assess the state of all significant construction projects annually. At its base after the detection of differences in the values of precipitation, annual monitoring is only required for structures characterized by large their values.

The data of the second thirty-year observation period show a significant increase in the intensity of vertical movements of a number of buildings and structures. Especially high was the level of anthropogenic risk due to significant differences in the values of precipitation in different parts. As a
result, during the 26-year period, changes in the marks of sedimentary marks in areas with adverse hydrological conditions caused by the rise of groundwater level due to man-made leaks of worn pipelines were: administrative building-53–18 mm, service building №1 – 74 – +1 mm, buildings of electrolysis-135-60 mm, medical building-91-14 mm, building of chemical water treatment– 25 – +62 mm.

At the same time, sedimentary marks of a number of other buildings and structures, which were in relatively favorable hydrological conditions or had a relatively small mass, were characterized by small movements in the vertical direction or uniform precipitation, which did not cause visible deformations of construction objects. The change in vertical positions of marks on them ranged from -6 to +8 mm. In this case, as a result of flooding (well, it was water) caused a subsidence of even one of the deep frames.

The above indicates that to ensure quality monitoring of geodetic observations processing and analysis of their results should be carried out over a long period. A prerequisite is the timely restoration of damaged sedimentary marks.

No less important for the assessment of technogenic risk are the data characterizing the stability of the position of technological equipment of industrial facilities and, first of all, bridge crane tracks. Safety of operation of cranes, first of all, is determined by the degree of preservation of the original geometry of crane tracks. Due to the sediment of the foundations, deformation of crane structures and the impact of other factors, the mutual position of the rails changes. As a result, normal operating conditions of cranes are violated, which can cause accidents. With a significant deviation of the track width from the design value of the valves can go off the rails, while the high longitudinal or transverse slopes are reasons for the self-motion of lifted goods along or perpendicular to the directions of rails. Identification of the degree of compliance with the state of crane tracks technical requirements, performed as a result of technical control determination of the actual track width, straightness of the rails, the longitudinal slopes of the track and the comparison of the values of deviations with the tolerance.

Assessment of the crane track is made according to the planned-altitude geodetic survey. At identification of the deviations of the geometrical parameters exceeding tolerances, operation of cranes shall stop. The technologies of performing geodetic observations of crane tracks are fully described in a number of works [20, etc.]. They set out in detail the technology of geodetic works to determine the various parameters of crane tracks in the shops of industrial enterprises. However, of the proposed methods of geodetic works, most are not quite rational.

Thus, the recommended methods of measuring the gauge (microtriangulation and quadrangle), based on a large number of angular measurements, are too time-consuming. Direct measurements are more appropriate. The technology of measuring the distance between the rails by steel tape measure with the introduction of amendments for the sagging of the web is also inefficient. It can be used only under the condition of cessation of work of the cranes that are impossible in a continuous production process.

Measuring the gauge is advisable to perform a laser rangefinder (laser tape measure). Its application significantly speeds up and makes the working process less time-consuming without reducing accuracy. So, if the average quadratic error of measurement steel tape measure track width of 10 m is 1.2 mm; 20 m – 1.5 mm; 30 m _ 1.8 mm; 40 m – 2.2 mm [20], the modern laser tape measures it exceeds 1.5, rarely 3 mm. For maximum performance it is advisable to use simple devices, providing installation roulette and reflector above the axis of the rails.

Determination of straightness of the rail axes is still the most appropriate method of alignment measurements. In the method of optical alignment " as the alignment line is used sighting beam of the visual tube of theodolite. The value of non-parallelism of the rail and the alignment line is determined by the method of lateral leveling. The technology of geodetic works described in [20] is based on the fact that, according to the authors, the parallelism of the rails does not arise mainly due to their one-way wear under the influence of the running wheels of bridge cranes. Therefore, they believe that the
heel (zero touch) Reiki need to align with the axis of symmetry of the lateral faces of the rail, the point of which, it is proposed to put the core on the top side of his head.

The experience of our work at the Volga pipe plant testifies to the irrationality of this technique, since the fixation of the points of the rail axes and the implementation of lateral leveling by combining the heel of the rail with them in low light conditions of the crane tracks are very complex and time-consuming. It is much more expedient to combine the heel of the rail with the side face of the rail. To justify the legality of the use of this method, we conducted an analysis of the progress of wear of the side faces of the crane track rails. It is revealed that even in the shops with the most intensive operation of cranes heavy-duty wear—this is small and does not exceed 5 mm. Thus, the discrepancy with the proposed method due to unilateral wear of the rail cannot be more than 2.5 mm, i.e. does not exceed the error of geodetic observations.

Even less expedient is the use of a very laborious method of "string" in which the authors [20] proposed between the extreme points of the rail axis to pull a string of thin wire or nylon thread and measure the distance between the string and the points of the rail axis with a ruler with millimetric divisions.

The main method for determining the high-altitude position of crane tracks is geometric leveling with the installation of rails directly on the rail heads. The most rational way to perform work on a closed course with the installation of the level at the points located on the opposite side of the track from the leveled rail. Closing of the course should be carried out on the rigid point of the angular column which is not the carrier for the crane rail.

From the above it follows that the rational execution of geodetic works necessary to identify the state of buildings, industrial buildings and technological equipment and assess the technological risk of their operation is possible only on the basis of a creative approach to the development of methods of geodetic observations, which leads to the achievement of a sufficiently high productivity while ensuring the necessary accuracy of measurements. To do this, an analysis of a set of conditions for making observations in each specific object should be performed.

A prerequisite for the objective assessment of man-made risk in the operation of buildings, structures and their technical equipment is the use of geodetic observation materials for a long period of work. Only consistent analysis of observational data on the condition of buildings, structures and technological equipment will make it possible to identify and eliminate errors, establish the reasons for obtaining conflicting data and determine the need for adjustments. The results obtained correspond to reality fairly accurate materials that provide the opportunity to maximise valid conclusions that lead to the development of effective rational proposals on measures to eliminate conditions that cause technological risks.

4. Conclusion
From the above it follows that the rational execution of geodetic works necessary to identify the state of buildings, industrial buildings and technological equipment and assess the technological risk of their operation is possible only on the basis of a creative approach to the development of methods of geodetic observations, which leads to the achievement of a sufficiently high productivity while ensuring the necessary accuracy of measurements. To do this, an analysis of a set of conditions for making observations in each specific object should be performed.

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