Technological problems of protection of coastal urban areas

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Abstract. Construction and operation of shore protection constructions are associated with a detailed study of abrasive and erosion-landslide processes in the coastal zone. Unfortunately, there are cases when due to the wrong choice of the type of constructions, violations of the technological process during installation is a complete or partial destruction of shore protection structures. The investigations show a low efficiency of individual shore protection measures, as well as a large number of deformations of structures on coastal fortified areas caused by the violation of technological standards in construction. It is also necessary to note the outdated methods and technologies of coastal protection used in the Volgograd region, which should be replaced by more modern and effective. Modern technology of construction of such structures will prevent the impact of abrasive processes and preserve the natural landscape of the site.

1. Introduction
Problems related to the protection of the banks of reservoirs and rivers from wave effects, currents and level fluctuations are given serious attention. The process of destruction of the banks is very active and causes significant damage to the national economy [1,2]. In the danger zone there are all coastal settlements without exception. In the conditions of river level fluctuations there is a problem of protection of the banks, for the solution of which special constructions of various types and designs are built.

The construction and operation of shore protection constructions involve detailed study of the abrasion and erosion-landslide processes in the coastal zone, based on the concept of lithomonitoring [3-5]. Studies of the processing of banks of the Volgograd reservoir of the rivers Volga and Akhtuba allowed to perform the analysis of the factors and the dynamics of the development of processes [6-9]. Such analysis required the processing of a significant amount of statistical and cartographic information, which would have been impossible without modern information technologies [10]. All stages of the development of GIS – from data collection, storage, conversion to information modeling and decision making in conjunction with software and technological tools are combined under the general name of geoinformation technologies (GIS – technologies). The purpose of GIS is the assessment, prediction and management of environmental change that is consistent with the objectives of the monitoring the adopted concept.

In accordance with these provisions, the paper applies traditional engineering-geological and geodetic methods for monitoring of processes and modern GIS-technologies for processing of observational data, their storage and use. First of all, it concerns mapping the distribution and activity of engineering-geological processes with the use of the methods of creation of digital maps and
creation of cartographic data bank on the basis of the developed methodology, the structure and content of engineering geological maps.

The series of maps needed for the assessment of engineering-geological condition of the territory and monitoring, should provide the most complete and detailed display of the actual geotechnical information; geographically-differentiated display of the dynamic parameters of the processes required to develop recommendations for the protection of territories and facilities; timeliness of information and the possibility of its renewal; maximum visibility maps, their accessibility to a wide range of users. The creation of digital cartographic base is the first phase of any compilation of thematic maps. Without dwelling on the description of methods of creating digital maps, we note only that the engineering-geological maps of reservoir sites and observations include the following layers: topographic base and the hydrographic network, genetic types and parameters of the slopes; stratigraphic and genetic complexes of surface sediments; the nature and form erosions.

It is important to note that the use of GIS-technology of lithomonitoring allowed not only to store and visualize the data of observations, but also to establish links between factors and processes, to identify patterns and trends in their development, to give predictive estimates and to make management decisions on the construction of protective structures.

Unfortunately, there are cases when due to the wrong choice of the type of constructions in the design, violations of the technological process during installation, as well as irregular maintenance there is a complete or partial destruction of shore protection structures. In such cases, the erosion of the shoreline and other processes begin again, and the protective structures need urgent repair, which often requires large financial investments.

Thus, during the survey of the banks of the Volgograd reservoir and the Volga river, a number of coastal areas with the destruction of shore protection structures, definitely caused by non-compliance with technological processes in construction, were identified.

2. Section 1
It is located within the boundaries of the garden association "Builder" in the village near city of Volgograd (figure 1). This construction protects the shore and prevents erosion of garden plots located near the bank with capital structures, as well as the destruction of the pumping station, which provides irrigation water to the entire country estate.

Shore protection measures are made here of concrete slabs, reinforced with reinforcement, and installed on a crushed stone pillow. This design is weakly opposed to wave dynamic loads, which resulted in the undercut of its base, which led to a partial caving of the crushed stone cushion and deformation of concrete slabs. Bad waterproofing joints contributed to the tearing of the construction inside the frosty time. The trees and shrubs growing between the slabs also have a negative impact,
which violate the density of the structure of the root system. The situation is aggravated by the sticking out reinforcement, which represents a high degree of injury for summer residents and especially bathing children.

Under these circumstances, there are several options for strengthening the slope: repair of existing structures or dismantling of plates, followed by the use of modern flexible protection method. At repair of already available constructions it is recommended to replace a crushed stone pillow on concrete with the subsequent installation of new plates. In the underwater part of the slope of the plate it is required to overlap [11-13]. Upon completion of the work, it is necessary to make the sealing of the seams and their subsequent waterproofing. This method will require large financial costs, and the repair period may be delayed for a long time due to the large amount of work [14-16]. The most rational solution for this case is the dismantling of the old shore protection structure and the strengthening of the slope with flexible protection structures. Based on the steepness of the slope and its role, a geogrid is quite suitable for protection, but the most effective way is the device of gabions [17-20]. Modern technology of construction of such structures will prevent the impact of abrasive processes and preserve the natural landscape of the site. They do not need annual maintenance, and their device will cost the city budget 30% cheaper than strengthening the slope of the plates.

3. **Section 2**

Located on the left bank of the Volgograd reservoir in the village of Kislovo Bykovsky district. The site is located on a flat, almost horizontal surface of the Khvalyn terrace, which has a small general slope (not more than 3°) towards the reservoir. The coastal ledge of the reservoir is steep, almost vertical, having a slight decrease to the central part of the village. The height of the coastal ledge is 8.3 m in the North of the village, 3.2 m in the central part and 4-5 m in its Southern part. The speed of processing of the shore in some areas reached 4.2 meters per year. A few years ago, an attempt was made to strengthen the coastal slope in the central part of the village, where preparatory earthworks were carried out and concrete slabs were laid on the ground (Figure 2).

Protection of the coast was conducted with violations of construction technology. Insufficient compaction of the soil, the absence of any foundation cushion led to the erosion of the soil under the plates and their further deformation. The lack of works to strengthen the slope in the underwater part of the coast only accelerated the erosion and aggravated the consequences. The activities carried out were ineffective, the coast continues to develop actively and there is no tendency to the attenuation of the process.

![Figure 2. The attempt of strengthening the coast in Kislovo.](image)
The most efficient way would be to use technology to strengthen the gabion or geotextile, and the absence of significant pressure on the ground from the capital structures allows the use of cement grunt here. It is also possible to combine these methods, based on the conditions of the structure of the shore. Such methods of securing the shore would significantly reduce the cost of shore protection measures, facilitate installation work and eliminate further costly repairs.

4. Section 3
Shore protection facilities in the city of Dubovka, built in 2014, have established themselves on the positive side. The abrasion processing of the bank were able to completely stop, and thereby prevent the destruction of an entire street with residential houses and household plots, which had previously been under threat. This strengthening structure stretches along the shore for a mile and is a concrete block, laid in several tiers on a crushed stone pillow. The stability of the coastal slope is provided by the decrease of the slope and impingement of the tetrahedrons in the underwater part of the coast. Unfortunately, in the course of the survey of the protective structure, a site was seen where, due to insufficient soil compaction, as well as the undercut of the crushed stone pillow with water, the sagging of concrete blocks occurred (figure 3). At the moment, this defect is not critical and is not an emergency, but will require further monitoring and possible repair. However, to increase the service life of these protective structures should be replaced with a concrete pillow crushed stone, make a connection of concrete blocks with cement mortar with complete waterproofing of all joints and organize periodic filling of tetrahedrons instead of the lost.

5. Section 4
Deployed in the Kirov district of the city of Volgograd in the area of the chemical plant "Khimprom". On this part of the bed Volga river makes a turn, so the shore protection constructions here perform a particularly important role and protect the shore from strong wave effects, as well as protect the coastal zone of the industrial enterprise. The shore protection structure is a short section of the coastal strip, fixed with concrete slabs connected to each other, as well as a wave-breaking banquet installed on top, simultaneously performing the role of a fence. This method of protection is most common in the Volgograd region and is similar in its design to the shore protection in Svetloyarsky district and on embankment in the Kirov district. It should be noted that the chemical plant has not been working for a long time on the maintenance of protective structures. This is evidenced by a large number of shrubs and small trees that grow between the plates and violate the density of the construction. At the bottom
of the contiguity of the construction to water the visible gullies, which over time will become bigger and will lead to the destruction of the plates. Special attention should be given to a number of areas where due to soil settlement and erosion has occurred a partial destruction of the covering of the construction and protecting of the banquet (figure 4). Violation of the integrity of the structure will contribute to its further destruction, especially in the rainy period and with snow melting. In addition, one of the main reasons that caused the destruction of protective structures is the corrosion of metal and reinforced concrete structures as a result of the impact of liquid aggressive effluents.

For the reconstruction of this site will require partial dismantling of the plates around the affected area, filling and compacting the soil with a set of reinforcing measures and the subsequent pouring of concrete for the base of the plates. Installation of new plates should be made with the subsequent processing of seams with bitumen solution.

The most rational would be to use the technology of strengthening the gabions or geotextile, and the absence of significant pressure on the ground from the capital structures allows the use of cement ground here. It is also possible to combine these methods, based on the conditions of the shore structure. Such methods of fixing the shore would significantly reduce the cost of shore protection measures, facilitate installation work and eliminate further costly repairs.

Conclusion. The studies have shown low efficiency of individual shore protection measures, as well as a large number of deformations of structures on protected areas caused by the violation of technological standards in construction. It is also necessary to note the outdated methods and technologies of coastal protection used within the boundaries of the Volgograd region, which should be replaced by more modern and effective. Activities to survey the coastal areas of cities, including shore protection facilities, help to identify problem areas at an early stage and prevent serious consequences, therefore need to be carried out annually in the monitoring system.

Figure 4. The destroyed site of bank protection in the Kirov district.

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