IRSTI 67.11.33

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https://doi.org/10.55956/KYOO6370

STUDY OF THE SAFETY OF GABION STRUCTURES IN THE CONDITIONS OF URBAN ENVIRONMENT

Abstract. The present work is devoted to the study of the safety of gabion structures in an urban environment on the example of bank protection of a pond near "Piramida" shopping center in Samara. Based on current regulatory documents, the safety level for humans at the construction and operation stage was estimated, as well as for the environment. It has been shown that the quality of work performed has a significant impact on the level of safety. Violations of the requirements of regulatory documents allowed during the construction of the structure led to the emergence of risks for the townspeople, as well as to a decrease in the quality of the pond water.

Keywords: urban environment, safety, gabion structures, bank protection, materials in construction.

Shabanova A., Zakirova M., Chuprina E. Study of the safety of gabion structures in the conditions of urban environment // Mechanics and Technology / Scientific journal. – 2024. – No.3(85). – P.270-275. https://doi.org/10.55956/KYOO6370

Introduction. Gabion structures have long been successfully used in hydraulic engineering [1], road and railway construction, as well as in the field of land reclamation [2]. This fact is explained by the simplicity of the construction of gabion structures, a rather long service life and a peculiar appearance. In recent years, gabions have begun to be widely used in urban environments as well. So, it is reported about their use in design of the administrative buildings [3], as well as educational institutions.

The experience of using gabions in urban recreational facilities seems to be especially interesting. The design features, in particular, its air and water permeability, and, consequently, a high degree of bio-positivity, allow solving a wide range of problems, for example, the construction of vertical gardens [4], which seems to be a very promising solution in the face of an acute shortage of territories specifically for recreation purposes. Gabion structures are especially widely used in the city for the purposes of bank protection of small water bodies - both independently [5] and as part of bio-positive hydraulic structures [6].

The peculiarities of urban environment make us impose particularly strict requirements for the applied constructive and technological solutions from the standpoint of various aspects of safety and at all stages of the structure's life cycle.

With regard to gabions, this issue has not been sufficiently addressed in the literature to date. This fact can be partly explained by the small practical experience in operating gabions in the city, as well as by the weak development of methodological approaches to the comprehensive safety assessment. Therefore, the purpose of the present work was to study the safety of gabion structures in an urban environment for both humans and the environment at different stages of their life cycle.

Materials and methods. The object of the study in this paper is limnological complex, located near "Pyramida" shopping center in Samara. The complex is formed by two ponds, received in the literature conventional names of Round and Long. According to the data available from us, these ponds were organized by the construction of a soil dam on a ravine for the goals of fisheries at the end of the XIX century. Currently, the limnological complex has become the center of an intra-quarter recreational facility. In 2013, within the framework of the city program for the rehabilitation of reservoirs, the ponds were cleared of aero-aquatic flora, and the banks were reinforced with gabion structures [7].

Safety assessments of gabion structures for environmental and human components were carried out for three stages of the life cycle - manufacturing of a structure (gabion), its installation and exploitation. At the stages of fabrication of the structure and its installation, the safety level was assessed by analyzing the design and regulatory documentation.

To assess the impact of the structures on pond water quality, samples were taken in summer and autumn and analyzed using standard methods for 27 hydrochemical indicators. Standard values of hydrochemical indicators were taken according to [8]. The safety of shoreline protection for recreants was assessed by visual inspection of the gabion structures and surrounding area, as well as by the interview method.

The safety of gabion structures at the stages of manufacturing and installation was assessed using the current regulatory documentation in relation to two aspects: labor safety and the quality of work performed.

Prior to the start of the works on the construction of the retaining wall from gabions, a set of organizational and technical measures was carried out in accordance with the requirements of the current regulatory documents in the field of labor safety in construction [9,10]. According to health and safety requirements, the work was allowed to persons over 18 years of age who passed a medical examination in accordance with the procedure established by the Ministry of Health of Russia. The workers of all specialties and qualifications were given safety instructions. The workers were timely provided with a personal and collective protective equipment at the expense of the employer.

Prepared prior to the start of the work, the construction site was provided with electricity, fire-fighting equipment, lighting, arranged entrances and exits. Temporary sanitary facilities functioned at the construction site to create the necessary working conditions, food and rest for workers [9-12].

Before the construction of the retaining wall of gabions, preparatory work on the delivery of gabion mesh products and gravel to the construction site was carried out, as well as the axes of the retaining wall were made [13-14,9].

When constructing the retaining wall, box gabion products were assembled, installed at the design elevations and secured with metal anchors, individual structures were combined into a single system and filled with stone. All works on the construction of the retaining wall of gabions with on-site filling with stone were performed in accordance with the requirements of regulatory documents [15,16].

Delivery, unloading, storage of gabions and filling them with a stone were carried out using a mechanized unit, including a dump truck, a wheel loader and a jib-type crane, which contributed to reducing manual labor at the site.

Throughout the entire period of the gabion retaining wall installation the quality control of the works was performed, which included the incoming inspection of the working documentation and incoming materials as well as the quality of the performed previous works, operational control of individual construction processes and technological operations and acceptance control of the performed works with the conformity assessment.

Research results and discussion. The safety of operation of gabion structures is largely determined by the quality of work on the implementation of design solutions, as well as the quality of materials used in the construction (mesh, filler).

Reliability of gabion construction is determined by the quality of double-torsion wire mesh, which should have an ultimate tensile strength, depending on the diameter and size of cells, from 30 to 53 kN/m. It is also important to comply with the requirements for stone materials used to fill gabions. Any stone material can be used to fill gabions, as long as it has the necessary strength, frost resistance and water resistance. The stone must not have signs of ablation, interlayers of soft (loose) rocks or other soluble inclusions. Manual placement of stone in a gabion should provide the apparent density of stone material over 17.5 kN/m^3. The minimum linear size of the stone must be more than 1.3 nominal mesh size of the grid, the maximum size of the stone must not exceed 250 mm. It is allowed to apply a smaller stone, but in volume, not more than 10%. The material should be laid evenly along the inner cavity of the gabion. Within 3-5 years, depending on the intensity of colmatation of rock material and consolidation of the foundation soil and backfill, gabion constructions gain maximum strength and serve for an average of 35 years. Poor quality material for filling gabions, weakness of the wire mesh led to deformation of the structure, loss of the aesthetic appearance.

As shown by the results of gabion structures survey of the pond shore protection near the Pyramid Shopping Center, a year after the commissioning of the facility damage and deformation of the mesh, as well as settlement of the filler are noticeable (Fig. 1).

Fig. 1. Fragment of gabion structures

This is the result of a gross violation of the abovementioned regulatory requirements for the gritter: carbonate rocks are used, which being in a zone of the variable level, are the subject of rapid destruction, which will inevitably affect on the level of gabions safety in the operational stage. The requirement for aggregate size of the stone was also ignored.

Safety of gabion structures at the stage of operation was assessed by us in two aspects – safety for recreationists and environmental safety.

The study of recreational activities carried out in the area adjacent to the pond showed that walks, as well as observation and feeding of birds (ducks live in the cattail thickets), were the most widespread. The main categories of recreationists are parents with children under the age of six, pensioners, as well as people with disabilities, including those with low mobility. Thus, the issue of the condition of the pond shoreline and the possibility of safe and easy access to water is of particular importance. As a visual inspection of the gabion structures showed, their current state is a source of risks for safe recreation: the integrity of the mesh in many places is broken, the gritter has shrunk, which led to deformations of the structure as a whole. During the interviews, recreants also expressed concern about the state of the bank protection, which has become unsafe, in particular for children.

Pond in an urban environment should be considered not as a natural, but as a natural-anthropogenic object, which makes it necessary to assess the level of environmental safety firstly in terms of justification of the management decisions taken. There are a number of regulatory documents for water quality assessment of water bodies, information about which is summarized [17] in Table 1.

Table 1

Regulatory framework for ensuring the safety of urban water bodies

Functional purpose of the reservoir	Normative document regulating safety requirements	Note
Fishery	State Standard 17.1.2.04-77	This function is lost now
Drinking water supply	State Standard 27-64-84	Until the beginning of the 20th century the ponds were used for drinking water supply in summer cottages
Recreational	State Standard 17.1.5.02-80	Applies only to areas of organized recreation
Static water supply	Construction Directives and Rules 2.04.02-84*	A number of ponds are suitable as an additional source of water for firefighting
Decorative	No data available	Video environmental safety issues are not reflected in the regulatory literature
Natural area of preferential protection (natural sanctuary)	No data available	General issues of environmental safety are regulated by the Federal Law “On Natural Areas of Preferential Protection” and the “Regulations on the Nature Sanctuary”

As follows from Table 1, the water quality of urban water bodies today is not regulated, which makes it problematic to evaluate it from the standpoint of environmental safety. At present paper the results of pond water analysis were compared with the requirements [8]. As shown by the analyses of pond water before and after the construction of gabions, its quality has significantly decreased: the content of total iron increased threefold, the content of copper compounds increased

sixfold and the BOD5 value increased fivefold. One of the reasons was the destruction of cattail thickets in the process of preparing the slope for the construction of gabions. Aero-aquatic vegetation is a valuable element not only of the video-ecological component, but first and foremost of the pond's self-purification system. In addition, stone gabion bank protection based on galvanized steel wire mesh leads to acidification of water, the death of many aquatic organisms and the bloom of blue-green algae.

Conclusion. The study of the safety problems of construction and operation of gabion structures in an urban environment made it possible to reveal a whole layer of unresolved issues of both technical and regulatory nature. To the greatest extent, this applies to the stage of gabion operation, and especially – the assessment of their environmental safety. Safety assessment of gabion structures used for bank protection of urban water bodies will become possible when its legal status will be settled at the level of the Water Code of the Russian Federation and, in future, the requirements for the quality of their waters will be fixed in regulatory documents.

References

1. Komarov A.K., Ivanov I.A., Lundenbazar B. Theory and practice of construction of protective structures using gabions // Proceedings of the universities. Investments. Construction. Real Estate, 2019. Vol. 9, No. 1 (28). P. 78-89.
2. Tishchenko A.I., Senchukov G.A., Gostishchev V.D., Chelakhov V.Ts. Calculation of the stability of gabion retaining wall to protect the banks of the Tsimlyanskoye κeservoir from structural failure // Ecology and water management, 2019. No. 2.
3. Demidenko G.A. Gabiony-odna iz form landshaftnogo dizayna administrativnykh zdaniy v Krasnoyarske [Gabions are one of the forms of landscape design for administrative buildings in Krasnoyarsk] // Landshaftnaya arkhitektura i prirodoobustroystvo: ot proyekta do ekonomiki [Landscape architecture and environmental management: from design to economics] / Materials of Int. Sci. and Tech. Conf. – Saratov, 2019. – P. 54-56, [in Russian].
4. Deniskina I.S., Yurtaeva N.M., Mininzon I.L. The use of organic concrete and gabions as a new modern technology in creating of vertical gardens // International student scientific bulletin, 2018. No. 3-7. P. 1026-1029.
5. Smetanin V.I., Vlasov V.A. Methods of improving the state of water bodies in urban areas // Privolzhsky Scientific Journal, 2009. No. 1 (9). P. 148-152.
6. Kaluzhskaya E.I., Bosov M.A. Method of the construction of flexible biopositive bank protection // Bulletin of Transbaikal State University, 2018. Vol. 24, No. 1. P. 4-9.
7. Vasin A.E., Gerasimov Yu.L., Dyuzhaeva I.V., Sachkova Yu.V., Selezneva E.S. Invertebrates in the pond ecosystem on Amineva street (the city of Samara) in 2010 // Bulletin of Samarkand State University, 2012. No. 3/2 (94). P. 34-40.
8. State Standard 17.1.2.04-77. Nature protection. Hydrosphere. Indices of state and regulations for valuation survey of fishery waters. – USSR: National Committee on Standards at the Cabinet of Ministers, [?].
9. Construction Directives and Rules "Labor safety in construction. Part I. General requirements". – Resolution of the State Construction Committee of Russian Federation No. 80. – 12-03-2001.
10. Construction Directives and Rules "Labor safety in construction. Part II. Construction production". – Resolution of the State Construction Committee of Russian Federation No. 123. – 12-04-2002.
11. Construction Rules 48.13330.2011 "Organization of construction. Updated version of Construction Directives and Rules 12-01-2004". – Order of Ministry of Regional Development No 781. – 27-12-2010.
12. Corporate Standard 2.33.14-2011 "Organization of construction production. Background information". – Council of National Association of Builders, protocol No 22. – 5-12-2011.

13. Construction Rules 126.13330.2017 “Geodetic works in building. Updated version of Construction Directives and Rules 3.01.03-84”. – Ministry of Construction, Housing and Communal Services of Russian Federation No 1469/pr. – 24-10-2017.
14. Construction Rules 45.13330.2012 “Earthworks, grounds and footings. Updated version of Construction Directives and Rules 3.02.01-87”. – Ministry of Regional Development No 535/2. – 1-01-2013.
15. Construction Rules 70.13330.2012 “Load-bearing and separating constructions. Updated version of Construction Directives and Rules 3.03.01-87”. – Federal Agency for Construction, Housing and Communal Services No 109/GS. – 25-12-2012.
16. Corporate Standard 2.33.22-2011 “Gabion erosion preventing construction. General requirements for design and construction”. – Decision of the Council of National Association of Builders, protocol No 02. – 17-05-2013.
17. Shabanova A.V. Environmental safety of intra-quarter recreational facilities, including ponds // National secutity and strategic planning, 2015. No. 3 (11). P. 122-126.

Material received on 16.09.24.

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ҚАЛАЛЫҚ ОРТАДАҒЫ ГАБИОН ҚҰРЫЛЫМДАРЫНЫҢ ҚАУІПСІЗДІГІН ЗЕРТТЕУ

Аңдатпа. Бұл жұмыс Самарадағы «Пирамида» сауда орталығының жанындағы тоғанды жағалауды нығайту мысалында қалалық ортадағы габион құрылымдарының қауіпсіздігін зерттеуге арналған. Қолданыстағы нормативтік құжаттардың негізінде Құрылыс және пайдалану кезеңінде, сондай-ақ қоршаған орта үшін адам үшін қауіпсіздік деңгейін бағалау жүргізілді. Орындалған жұмыстардың сапасы қауіпсіздік деңгейіне айтарлықтай әсер ететіні көрсетілген. Құрылысты салу кезінде рұқсат етілген нормативтік құжаттардың талаптарын бұзу қала тұрғындары үшін қауіп-қатердің туындауына, сондай-ақ тоғандағы су сапасының төмендеуіне әкелді.

Тірек сөздер: қалалық орта, қауіпсіздік, габион құрылымдары, жағалауды нығайту, құрылыстағы материалдар.

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ИССЛЕДОВАНИЕ БЕЗОПАСНОСТИ ГАБИОННЫХ КОНСТРУКЦИЙ В УСЛОВИЯХ ГОРОДСКОЙ СРЕДЫ

Аннотация. Данная работа посвящена исследованию безопасности габионных конструкций в условиях городской среды на примере берегоукрепления пруда у торгового центра «Пирамида» в Самаре. На основании действующих нормативных документов проведена оценка уровня безопасности для человека на этапе строительства и эксплуатации, а также для окружающей среды. Показано, что качество выполненных работ оказывает существенное влияние на уровень безопасности. Допущенные при строительстве сооружения нарушения требований нормативных документов привели к возникновению рисков для горожан, а также к снижению качества воды в пруду.

Ключевые слова: городская среда, безопасность, габионные конструкции, берегоукрепление, материалы в строительстве.