City Embankments as Unique Buildings and Structures. Modern Principles of Model Formation on the Example of the Coastal Zone of the Yauza River in Moscow

Vitaliy Kas'yanov and Vadim Danilchenko
Moscow State University of Civil Engineering, Yaroslavskoe shosse, 26, Moscow, 129337, Russia
E-mail: vadim.dkr@mail.ru

Abstract. The growth of modern megapolises leads to the degradation of natural resources on their territory, this leads to the destruction of the urban ecology and the deterioration of the citizens’ healths. The territories located along the coastlines of various reservoirs located within the city, conceal a huge potential for improving the quality of life of the urban population. In particular, the coastline of the Yauza River, flowing within the city of Moscow, can be not only a carrier of the historical type of urban landscapes but also a great area for recreation and comfort of Muscovites and visitors. Today these territories are used irrationally, the city strengthens the expansion on the coastal zones, and the technogenic influence leads to not only the pollution of the coast but also of the Yauza channel. The main problem raised in this article is the problem of methodological approaches to the development of waterfront development projects.

1. Introduction
There is a natural or artificial waterbody in almost every large settlement within its boundaries. However, the natural coastline of such a reservoir is not suitable for the full use by citizens. Boggy, overgrown with bushes and reeds or steep banks do not allow you to organize a full rest or travel for personal needs. A shallow coastal zone overgrown with reeds creates an unfavorable appearance and prevents access to water. In this regard, there is a question about the improvement of the coastline of natural and artificial reservoirs within the settlements. The construction of embankments on these sites is considered to be the most effective way. [1-4]

This article discusses the construction of embankments along the coastline of the Yauza River in Moscow.

2. Materials and Methods
Conventionally this coastline can be divided into four sections:

1. The site from the river source to the Yaroslavl highway. On this-upper-segment of its flow Yauza is a wild pond with shaky, overgrown with bushes and reeds, banks. The coastline is rarely used, mainly by fishermen.

2. Mytishchi area – defined as the coastline of the Yauza river from the Yaroslavl highway to MKAD. The coastline is sometimes used as a recreation area for citizens.
3. Upper-Moscow site – located on the stretch of the river from Moscow to Sokolniki. The banks of Yauza are mostly in a natural state, but quite large areas are improved for use in industrial zones, for walking areas and embankments.

4. Nizhnekamskiy site is located from the Sokolniki district to the Yauza mouth. In this segment, the river is bounded with stone banks, has decorative fences, sidewalks, bridges.

Let's consider, what modern principles of formation of embankments’ models are necessary to use during the construction and the reconstruction of embankments of the Yauza river. According to the "Code of rules for design and construction" embankments are complex engineering structures located along the coastline of a natural or artificial body of water up to the water cut. The most common type of embankment is a retaining wall. Less common is the construction of such a structure in the form of an overpass pile structure with all associated and auxiliary structures and works [5].

Storchak Y. A. in his article "Formation of building and transport communications in the areas belonging to the city embankments” defines the tasks and functions of embankments:

1. A clear fixing of the boundaries of the water edge;
2. The protection of a bank from erosion, erosion by the current, wave, and often atmospheric (water, temperature, wind) erosion;
3. The strengthening of bearing capacity of coastal soil;
4. Providing convenience for a range of activities closely related to active and passive recreation near the pond;
5. Often - providing the possibility of mooring to the bank of watercraft [1-3].

The function of fixing the boundary of the water cut of the embankment is manifested in the compensation of temporary, seasonal or technological (in reservoirs) fluctuations in the water level due to the height of the structure. The embankment towering over the water is able to effectively contain flood waters and extinguish the waves. To reach the berth depth even in the dry period, part of the embankment is carried deep into the water area. The function of strengthening the bearing capacity of the coastal soil is defined in providing free passability along the embankment not only to pedestrians, but also to vehicles. Artificially fortified banks provide free access to water, while very often it is not possible on natural banks.

The embankment can become a convenient place not only for walking and cycling, but also for swimming, fishing and other forms of active recreation of citizens.

The embankment must be equipped with a berthing wall to perform docking to the bank for watercraft (yachts, boats, etc.), landing-disembarkation of passengers, loading and unloading.

The need for the arrangement of embankments within settlements arises regardless of the depth of the reservoir. This parameter affects only the choice of engineering methods for solving the problem, for example, construction works from the bank, or combined from the water and from the bank [2, p. 43].

Rybalkina Y. S. in the article "Principles of formation of public spaces of quay territories" indicates that the construction of modern design projects of coastal zones in settlements must take place in accordance with the following principles:

1. The principle of humanization of the spatial environment;
2. Parity of natural and artificial elements;
3. Biopositivity;
4. Formation of a single urban-ecological framework of the city
5. Investment attractiveness of the project
6. Formation of innovative ultra-modern reflection of the urban environment in the form of embankments [5].

The principle of humanism in the construction and reconstruction of embankments is implemented in the creation of landscape and design, convenient for citizens. The principle of parity of natural elements is expressed in creation of balance between natural components and elements of architecture. The principle of biopositivity is expressed in a careful attitude to the natural conditions of the area on
which the embankment is located. The design of the construction should have a maximum of natural materials. The formation of a single urban-ecological framework of the city means the balance of the urban environment with natural areas that perform environmental, health and recreational functions.

The investment attractiveness of the project is the answer to the question: how is it possible to equip the coastline so that these works will be compensated in the future?

In the "Album of standard solutions for the improvement of embankments" noted that the shape and construction of the embankment is largely determined by the line regulation of the reservoir - the intersection of the plane mirror of the pond at low-water level or at the level of continuous support with the plane of the coastal slope or retaining wall of the embankment. The distance between the river control line and the red line of urban development is the coastline. The distance between the upper edge of the slope and the red line of urban development is the embankment. Sometimes the zone of the coastal slope disappears, merging into one line with the retaining wall of the embankment. The outline of the embankment in the plan can be very diverse: rectilinear, curvilinear, and the transverse profile of the retaining walls vertical or inclined. Along the top of the walls, fences are always installed, as a rule, cast-iron grilles with bollards or a solid stone parapet [6].

Depending on the horizon of moderate and high waters and the height of the bank embankments can be one-, two- and multi-tiered. One-tier embankments are arranged at a height of the wall up to 5-5.5 m. The construction of higher walls from an architectural point of view is impractical (they are very bulky). In this case, based on engineering and economic considerations [7-9] embankments should be given tiered outlines with vertical walls or a combination of a wall with a slope having a slope of 1:1-1:1.5 and reinforced with stone or landscaped.

On navigable sections of the river embankment must be obligatory equipped with a pier. If the embankment is arranged along small rivers, streams and other places of active discharge of spring meltwater and storm flows, the edge of this structure should be raised above the level of the natural shore by at least a meter. This is done to avoid flooding in case of sudden large amounts of precipitation or active melting of the snow cover.

When planning the improvement of the coastlines of water bodies, it is necessary to take into account the risks - for example, possible river floods or floods, soil erosion, etc. On navigable sections of the river, the embankment must be equipped with a pier. If the embankment is arranged along small rivers, streams and other places of active discharge of spring meltwater and storm flows, the edge of this structure should be raised above the level of the natural shore by at least a meter. This is done to avoid flooding in case of sudden large amounts of precipitation or active melting of the snow cover. Here we come close to the problem of assessing the impact of the external environment on the structure. [10,11]

When planning the improvement of the coastlines of water bodies one should take into account environmental risks, for example, possible river floods or floods, soil erosion, etc. when designing embankments and building models one should take into account all the adverse effects, because in case of errors there can be serious environmental and humanitarian consequences. In the paper by Kasyanov V., Danilchenko V. Environmental risk Management (Environmental risk management. Forecasting and modeling of emergency risk management situations) [6], the main goal of risk management from the creation of the project to the completion of the embankment, is believed to reduce the level of risks to acceptable values. In practice, there may be several alternative projects of construction or reconstruction of one object. Quantitative risk assessment allows to identify the most dangerous factors, to choose less dangerous from several alternative projects, to use databases of expert systems for the development of regulatory and construction documentation and even to determine priority areas of investment that will help to reduce or completely eliminate possible risks [12-15].

There are several common methods to minimize environmental risks before the construction or reconstruction of the waterfront. These are activities such as:

1. Floodplain lowering aimed at widening the riverbed in case of flooding;
2. Ensuring stability of the desired depth of the waterway and increasing, if necessary, the flow rate;
3. Moving the dam into the area to increase the capacity of river water;
4. Elimination of obstacles to the flow of the river by conversion or mixing, which allows, if necessary, to increase the flow rate;
5. Depolarization is aimed at the formation of zones of overflow in case of flooding;
6. Creating a reservoir that can act as a nearby lake. This option will avoid water shortages during an emergency;
7. Measures to deepen the channel, aimed at creating a greater capacity of the waterway;
8. Creation of the channel intended for discharge of flood waters and representing a certain part of the dam taken away from the bed of the main river;
9. Measures to strengthen dams in areas where river expansion is not required [16].

The author Efimova T. B. [17] defines the following main features of the construction of embankments at different stages of work:
1. Design surveys and design planning;
2. Carrying out a complex of preparatory and coast protection works, such as the construction of additional retaining walls, installation of geogrid and so on;
3. Arrangement of access roads to construction sites for construction equipment, clearing of construction sites from coastal and aquatic vegetation, if necessary – dredging and dredging works;
4. Construction on the water cut or with the removal of the main retaining wall into the water area of the reservoir. The height of this element is determined by calculating the flood and breakwater loads, the requirements of the device for regulating the water level by locks, the stability of soils for sinking sheet walls. In the case of navigability of the reservoir the height of the retaining wall is calculated depending on the berth depth;
5. Conducting backfill retaining wall filler-soil, gravel, sand - to the upper edge. Subsequent alignment of the site of the required width;
6. Formation of the necessary bearing strength of the embankment surface for pedestrian and transport passability by covering with tile, gravel, composite materials or reinforced concrete blocks;
7. Arrangement of convenient access roads and footpaths to the waterfront;
8. Placement on the embankment of fences, stairs, decorative elements, lighting points, mooring bollards and other "body kit" provided by the project;
9. The device of additional auxiliary structures-fishing bridges, piers, mooring walls, boathouses, beaches, swimming and recreation areas, with their integration into the overall architecture of the waterfront;
10. The final stage – carrying out landscaping of the embankment territory by means of laying of rolls of a lawn grass, breakdown of beds, tents, planting of decorative trees and bushes [17].

Figure 1 shows a model of construction and reconstruction of the embankments of the Yauza river in the North-Eastern administrative district of Moscow.
As you can see, the work plan contains the above features of the construction and improvement of embankments: cleaning of the riverbed, shore protection works, laying covered with modern materials hiking trails and bike paths, the device of observation and sports grounds, the breakdown of flower beds, lawn covering, installation of lighting equipment, CCTV cameras, and more.

For Russian cities, this problem is extremely relevant. The gloom of urban landscapes often exacerbates the depressed mood of the citizen by the poor condition of the components of urban space: crumbling road surfaces, gray facades of buildings, unkempt green spaces. The transformation of such areas into something completely opposite, open, colorful, has become the main trend of modern landscape architecture around the world. It is necessary to adopt foreign experience, thanks to which heavily affected by anthropogenic impact areas along the shorelines of reservoirs can be successfully turned into public parks, where anyone can fully relax both physically and psychologically [17, p.42]. Complex improvement is carried out in accordance with the norms of the town-Planning Code of the Russian Federation, the Code of rules for design and construction SP-35-101-2001, SP 42.13330.2011 and other existing legal Acts in the field of design and construction.

As an example of the reconstruction works carried out in the floodplain of the Yauza river, let us give the works on the improvement of the variety platform “Singing field” in southern Medvedkovo. Figure 2 shows the view of the object from the top before the reconstruction (A) and after the work (B).
During the reconstruction of the territory of the Singing field, a modern updated concept was used, combining landscape and functional elements that meet the interests of different groups of the population, while preserving the existing basic layout.

Keeping in mind the principle of investment attractiveness of the project, it should be said that in addition to emotional, psychological, cultural, historical, environmental potentials, embankments located along the shorelines of water bodies have a huge trade and economic potential. Since these areas have an appeal for citizens and guests of the city, near them, as a rule, a large number of shopping and entertainment centers. According To K. Dovey "all over the world to large recreational areas try to add as much as possible cultural, educational, entertainment functions and, of course, commercial" [18, p. 3].

According to the work of R. Forman, the project of giving comfort and aesthetics to the territories located along the shores of waterways includes a thorough study of all the necessary areas aimed at creating a certain functionality that is combined with the environment. Improvement of the embankment sections and all its infrastructure in General requires a competent approach to planning and improvement, pedestrian traffic and functional zoning [19, p. 6].
3. Results and Discussion

As a result of the analysis of examples from domestic and foreign practice, it becomes clear that the creation of projects of convenient embankments contains a huge potential associated with the urgent needs of the population. But the most important aspects of this design are, first of all, the development of options for citizens’ access to water resources, as well as the cleaning of the river and the maintenance (and, if necessary, restoration) of biological diversity in combination with the harmonious architectural ensemble of the city.

The resolution of the governments of Moscow No. 409-PP dated July 7, 2015 marked the beginning of grandiose transformations of the floodplain of the Yauza river over twenty-four kilometers of its course [20]. The new recreation area will create a single coastal space and form a linear Park equipped with modern Hiking trails and bike paths. Landscape and architectural design of the Yauza embankment will be as environmentally friendly as possible, which is already evident from the examples of the work carried out.

According to the results of consideration of possibility of use of modern variants of improvement of embankments there is a tendency to creation of the certain compositional plan inseparably connected with comfort and multifunctionality. Breaking long embankments into separate sections to give them diversity, emphasizing the most interesting natural advantages, transforming unfavorable areas, it is necessary to take into account the overall architectural and spatial solution of the entire waterfront.

4. Conclusions

All in all, based on the model of the complex infrastructure of the coastal areas is to be based on the principles underlying a systematic approach to the environment at the local level and in urban scale, at the level of planning and implementation of major projects of reconstruction and development of territories:

1. Integrity;
2. Spatial continuity;
3. Multifunctionality;
4. Cultural continuity;
5. Identity;
6. Ecological compatibility;
7. Aesthetic appeal;
8. Availability;
9. Seasonal dynamics, all-season adaptability;
10. Security [21].

All in all, the device of the embankment is not the construction of one hydraulic structure, but a whole complex of engineering and construction activities. [22, 23]. Its purpose is not only to strengthen the coast of the reservoir, but also the improvement of the surrounding area. The device of the embankment is one of the common ways of capital engineering equipment of the shore of the reservoir, which gives the most complete results. The use of natural advantages of the area, the preservation of valuable landscape areas, skillful additional planting of green spaces allow to create an interconnected system of green and water spaces, contributing to the formation of integral architectural and expressive urban ensembles.

References

[1] Storchak Y. A. Formation of buildings and transport communications in the regions belonging to the city's embankments. Bulletin of MGSU. 2017. URL: https://elibrary.ru/item.asp?id=30041859

[2] Lepkovich, I. p. Landscape art. Park construction, urban landscaping, biodesign; aesthetics of the countryside, estates, roads; national parks, reserves, reserves. I. P. Lepkovich. SPb. DILYA. 2004. pp. 400
[3] Rybalkina Yu. s. Principles of formation of public spaces of quay territories. Electronic scientific journal Apriori. Natural and technical Sciences. No.1. 2017. URL: http://www.apriori-journal.ru/seria2/1-2017/Rybalkina.pdf

[4] The Album of standard solutions for the improvement of embankments. G. I. Belyaev, D. V. Sadkov, A. I. Guk, O. M. Sadalskaya, G. A. Yushin, P. V. Klimov, K. R. Yakubova, A. S. Kulakov, A.V. Strebkov, A. A. Odintsov, I. G. Tsvetkova. Moscow Committee on architecture and urban development of Moscow 2016. page 568 URL: http://archsovet.msk.ru/image/upload/file/album-emb-mos.pdf

[5] Set of rules for design and construction. Embankments. The rules of design. First edition. Ministry of construction and housing and communal services of the Russian Federation. Moscow 2017. URL: https://upload/iblock/576/sp-naberezhnye.doc

[6] Kas'yanov V, Danilchenko V, Amelin V, Tolmacheva V. Environmental risk management. Forecasting and modeling of emergency risk management situations. MATEC Web of Conferences V. 251 2018. DOI: https://doi.org/10.1051/matecconf/201825106030

[7] Borkovskaya V G Complex models of active control systems at the modern developing enterprises. Advanced Materials Research. V. 945-949. Chapter 22: Manufacturing Management and Engineering Management. 2014. P. 3012-3015. DOI: 10.4028/www.scientific.net/AMR.945-949.3012

[8] Borkovskaya V G The concept of innovation for sustainable development in the construction business and education. Applied Mechanics and Materials. V.475-476. Chapter 15: Engineering Management. 2013. P. 1703-1706. DOI: 10.4028/www.scientific.net/AMM.475-476.1703

[9] Borkovskaya V.G. Complex models of active control systems at the modern developing enterprises. Advanced Materials Research V. 945-949. Chapter 22: Manufacturing Management and Engineering Management. 2014. P.3012-3015. DOI: 10.4028/www.scientific.net/AMR.945-949.3012

[10] Borkovskaya V.G. Environmental and economic model life cycle of buildings based on the concept of Green Building. Applied Mechanics and Materials 467. Materials Science and Mechanical Engineering, Chapter 2: Building Materials and Construction Technologies. P. 287-290. 2013. DOI: 10.4028/www.scientific.net/AMM.467.287

[11] Borkovskaya V.G. Post bifurcations of the concept of the sustainable development in construction business and education. Advanced Materials Research. V. 860-863. Chapter 26: Engineering Education. P. 3009-3012. 2013. DOI: 10.4028/www.scientific.net/AMR.860-863.3009

[12] Borkovskaya V G and Passmore D L 2019 Behavioral engineering model to identify risks of losses in the construction industry. Smart Innovation, Systems and Technologies, 243–250. doi:10.1007/978-3-030-15577-3_24

[13] Borkovskaya V G and Passmore D L 2018 Application of failure mode and effects analysis in ecology in Russia. MATEC Web of Conferences 193, 05027. doi:10.1051/matecconf/201819305026

[14] Borkovskaya VG, Degaev E, Burkova I. Environmental economic model of risk management and costs in the framework of the quality management system. MATEC Web of Conf., 193 2018 05027. DOI: https://doi.org/10.1051/matecconf/201819305027.

[15] Burkov V N, Burkova I V, Barkhi R, Berlinov M Qualitative Risk Assessments in Project Management in Construction Industry. Journal MATEC Web of Conferences, V. 251, 06027 2018. DOI: https://doi.org/10.1051/matecconf/201825106027

[16] Rybchinsky V. Urban designer: ideas and cities. M. Strelka press. 2014. P. 225

[17] Efimova T. B. Public urban spaces. City quay. Issues of planning and development of cities. Proceedings of the VIII international scientific and practical conference. Under the editorship of Y. V. Kruglov, I. A. Kheruvimova. Penza state University of architecture and construction. 2016. URL: https://elibrary.ru/item.asp?id=27601049
[18] Dovey K. Becoming places: urbanism/architecture/identity/power. K. Dovey. New York. Taylor and Francis. 2010.

[19] Forman R. Urban regions: ecology and planning beyond the city. R. Forman. Cambridge University Press. 2008. p. 408

[20] Resolution Of The Moscow Government No.P. 409. URL: http://mosopen.ru/document/409_pp_2015-07-07 (date of application: 06.10.2019)

[21] Ivanov A.V. Technology and organization of works in the construction of natural resources and water use. Textbook. A. V. Ivanov. M. ASV. 2014. c. 560

[22] Bolshakov N, Badenko V & Celani A (2018). Integration of territorial analysis methods in site selection on the example of Saint Petersburg. IOP Conference Series: Materials Science and Engineering 365, No. 2, 022052

[23] Bolshakov N S, Badenko V L, Celani A (2018). Site selection on the basis of territorial analysis methods. Magazine of Civil Engineering. 81(5), 15–24