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Application of Soft Fabric Structures for Improvement of the Selective Irrigation Intake of the Partisan Water Reservoir

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Application of Soft Fabric Structures for Improvement of the Selective Irrigation Intake of the Partisan Water Reservoir

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Abstract. To protect irrigation intake structures from the deposition of sediments (from bottom, middle, upper layers), which can be a source of secondary water pollution, a large number of different designs of sediment interceptors have been developed. Increasing requirements for withdrawn water quality from the watercourses for irrigation and water supply, necessity of reconstruction on a large part of the previously constructed headwaters and have led to the development of an effective protective device. In the 20th century, world population has tripled from 1.6 to 6 billion people, irrigated farming area increased from 50 to 267 million hectares, and water consumption increased six-fold - from 500 to 3,500 km³ / year. The real water shortage is provoked by increased demand, associated, according to experts and international organizations, with demographic boom, change in food intake of large groups of population, industry and energy development, urbanization and popularization of biofuels. Factors that reduce available water resources include inefficient water use, water pollution and, increasingly, climate change. This issue remains very important for the Crimea and its successful resolution will become one of the foundations for the sustainable development of the peninsula. Water resources are one of the factors of sustainable development of the territories on global and regional levels. Entire hydro transport system improvement of water resources delivery to the final consumer of the Crimea (population, agriculturally used areas, industry, tourist complex, etc.) is the main strategic issue on optimization of water resources potential and sustainable development of various sectors at the socio-economic sphere. It is supplied up to 80,000 m³ / day water for drinking purposes from the Partizansky Reservoir, 215,000 Simferopol residents use water from the Partizansky Reservoir for living. Partisan reservoir is the main source of water supply for settlements in Simferopol and Bakhchisaray districts.

1. Introduction

The water problem in the Crimea has always been particularly acute. The Crimean peninsula is in the south of Eurasia moderate belt, it is a joint of the southern part of a moderate belt and subtropical Mediterranean type of climate. That is why it is dry and hot during the warm period of the year (April-October) here, and the main amount of rainfall drops during the cold period of the year [1].

Therefore, it is possible to draw a conclusion on the reasons of fresh water deficiency in the Republic of Crimea:

- arid climate of the peninsula;
- silted mouths of the small rivers;



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- limestones promoting transition of surface runoff into underground. The main water supplies in the Crimea are artesian cavities of the flat peninsula;
- river beds of the mountainous part of the Crimea are made of limestones that enables considerable filtration and changing of surface runoff into underground.

There has always been a difficult situation with water in the Crimea and Sevastopol because the region is dry and the reservoirs have not replenished by rain and melt water to flood-control storage level during recent years. [2] Some part of the Crimea reservoirs is replenished from mountain streams and artesian wells, but as a matter of fact their filling changes every year and it is rather difficult to predict their water level.

Till the middle of the twentieth century the peninsula was practically waterless and ideas of artificial watering of the steppe part of the Crimea appeared at different time. This idea turned into a unique structure only in time of the Soviet Union. The North Crimean canal originates from the Kakhovsky reservoir on the Dnieper. The first stage of the canal was put into operation in 1978, the second in 1990, the third in 1997. Construction of the fourth stage was stopped in 1997 because of the lack of means. The fifth and the sixth stages were planned in the long- term perspective. The total length of the canal is 396.2 km, of which 292.7 km pass across the territory of the Crimea. The Ukraine has completely blocked the North Crimean Canal that delivered water for agricultural and industrial needs of the Crimea in April 2014, and after cutting off water supply it appeared to have no water in summer for the first time for a half of the century. The Crimean agricultural enterprises have sustained enormous losses because the fifth part of agricultural lands is irrigated on which more than a half of all crop production is received.

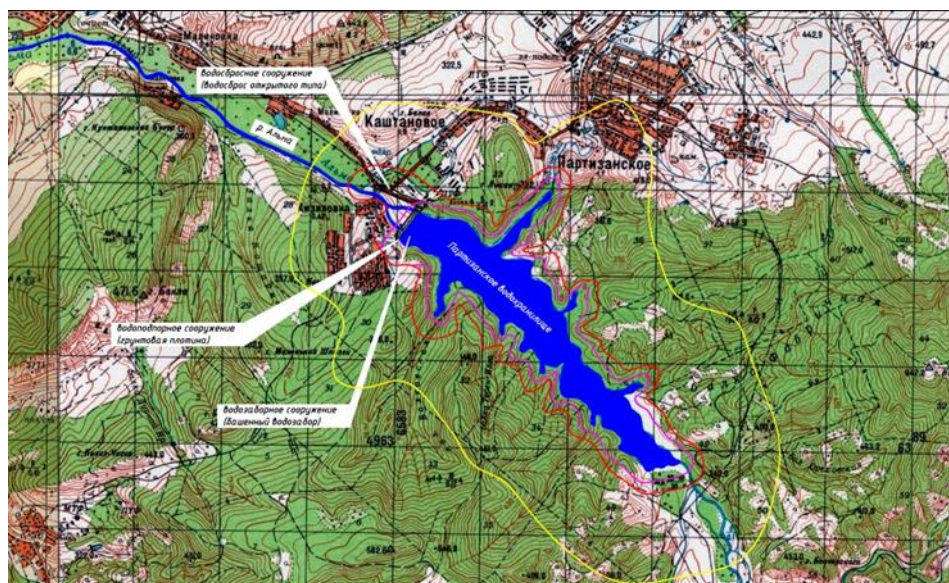


Figure 1. Site layout plan of the waterworks of the Partisan Water reservoir

- waterworks border;
- sanitary zone of the 1st belt (100 m, 200 m from the withdrawal point);
- sanitary zone of the 2nd belt (1 km);
- water protection zone.

The total annual needs in drinking water for constantly living population (2 million people) are about 250 million m³ of water per year that in general can be provided by means of the peninsula water resources. About 200 million m³ of water per year are necessary for the needs of vacationists (up to 3 million people during 6-8 months) that can be also supplied from the available resources [3].

The main pollutants of surface waters are communal facilities, they contribute 95% of the polluted waste discharge. Sewage disposal is carried out into surface water bodies and storage reservoirs. The volume of sewage discharge into surface water bodies in 2015 was about 120 million m³ [4].

On the territory of the Republic of Crimea 116 sewage treatment plants functioned in 2016 with a general capacity of 282.23 million m³/year, 46 of them discharged the treated sewage into natural water bodies, 70 sewage treatment plants discharged the treated sewage into storage reservoirs. Their capacities for the last 20 years reduced by 115 million m³/year because of complete wearing of the equipment and closing of certain stations. The volume of sewage discharge into water bodies increases because of severe wearing of water treatment plants. So, if their volume in 2000 was 56 million m³, then it increased up to 67.5 million m³ in 2009, having reached its maximum of 97.6 million m³ in 2011.

The importance of water in life subsistence and its wide usage in economic activity as raw material, solvent, heat conductor, transport environment is accompanied by the increase of volume of water resources selection and amount of discharged pollutants of anthropogenic origin. It defines protection and rational use of water resources as the most important environmental engineering problem connected with reviewing of reproduction technology according to ecological requirements [6].

Systemic environmental approach to water bodies should consider a complex of measures directed to reproduction of required ecological and technological costs, maintenance of balance of anthropogenic loading on water sources.

Maintenance of balance of anthropogenic loading with continuously proceeding hydrochemical and hydrobiological processes of life activity on water bodies sets a number of the most important water environmental problems that demand complex researches on development of the water protection technological schemes with the use of ecologically acceptable constructive decisions. Foreign and domestic experience of creation and improvement of structures and designs, with a tendency of reduction of construction and operation resource costs shows that the most perspective is the direction connected with use of high-strength synthetic fabrics as the basic structural elements of constructions.

The accumulated experience of application of soft structures in various regions of the Russian Federation in the field of water management has allowed to find out that constructive and functional features of soft structures allow to create the most perfect water protection technological schemes for water bodies [7, 8].

Rivers as the functioning object of nature are an important link in water cycle which mechanism works correctly if its basic elements (the catchment area, the floodplain, the course and the water flow) perform inherent functions [9,10]. Rehabilitation of working efficiency of the listed elements provides the performance of a complex of melioration measures. A lot of constructive solutions are known nowadays that provide use of both local (stone) and traditional (concrete, metal, wood) building materials. Structures built from these materials are designed for a long operation period and demand high material costs. Recovery processes take about 10 years under complex melioration measures on the small rivers [11].

Along with anthropogenic loading from economic activity water bodies are subjected to significant overloading from pollution by toxic substances of industrial and agricultural enterprises, transport (automobile and railway) crossing river courses. To establish the optimum mode for microorganism life activity within the botanical ground, creation of the mobile protecting designs which construction doesn't demand high material costs is required [12].

The water intake has to meet the following requirements:

1. The amount of water, even at the lowest level, has to provide water needs;
2. Water intake inlets shouldn't be clogged;
3. The water intake structure has to be steady and endurable, despite the influence of various factors;
4. Water withdrawn from a reservoir at different time of the day and the year has to be of the best quality possible.

When intake water from the reservoirs, the following should be taken into account:

- water turbidity because suspended sediments can clog water intake inlets;
- silt, sand, deposited by water as suspensions;
- algae and various floating items (plastic bottles, litter) can clog water intake inlets;
- bottom ice and slush can clog water intake inlets;
- water quality changes vertically. Near bottom layers are more turbid than middle and upper ones.

Upper and near bottom layers have the highest turbidity under flooding, that is why water intake is carried out from middle layers, and it is stopped under certain water turbidity.

Water problems in reservoirs:

- water salinization;
- water blooming;
- eutrophication;
- silting;
- pollution of water taken from the catchment area.

Installation of the device of high-strength fabrics to improve selective water intake from a reservoir and fresh water supply of settlements in Simferopol and Bakhchisaray districts (Fig. 2) at the continuously operated Partizansky Reservoir on the small river Alma (Fig.1) of the Republic of Crimea is proposed by the author. The device presents membrane fabric (Fig.3) resistant to decay, corrosion, destruction. It is applied as fish protection structure, for slush, plankton and suspended particles control, and interception of algae, small and large litter.

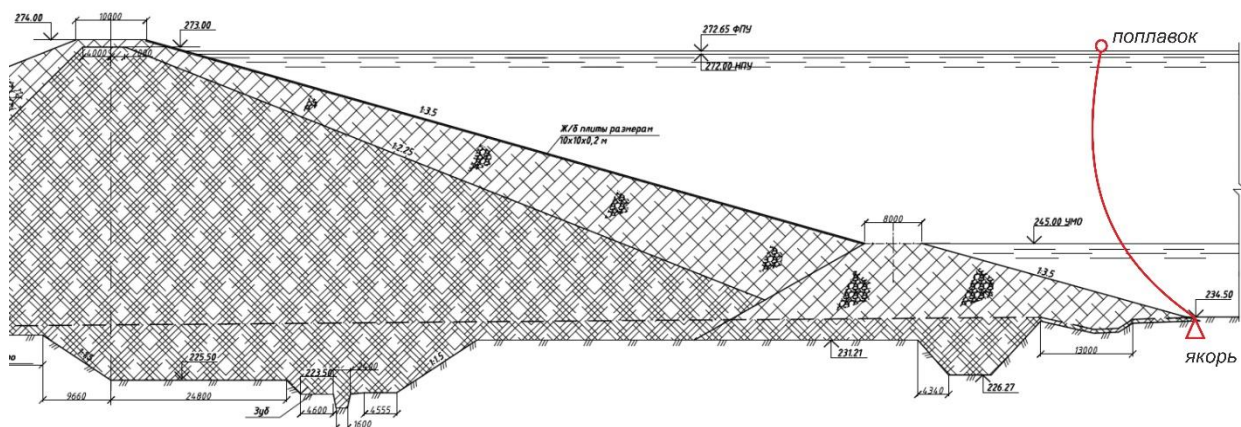


Figure 2. Installation of the device of high-strength fabrics at the reservoir.

The main material used for production of fabric structures are high-strength fabrics of different interweaving.

The term 'soft shell' was substantiated by professors Alekseev S.A., Goldenveizer A.L., Feodos'ev V.I. and others in 1960-s. Membrane shell unable to take compression pressure should be understood as a soft shell. Shell sizes exceed its thickness manifold (enormously) and provide moment-free point.

A soft waterworks structure is called a structure where a soft shell is the main operating component.

The soft shell can be either in two-dimensional stress state ($\sigma_1 > 0$, $\sigma_2 > 0$), when both main tensions are positive; or in single dimensional stress state when smaller main tension ($\sigma_1 > \sigma_2$) is negative ($\sigma_2 < 0$). In this case smaller main tension is accepted equal to zero ($\sigma_2 = 0$) and the shell in single dimensional stress state works as the system of absolute flexible threads. Under single dimension stressed soft shells, folds can be formed in the directions where smaller stress ($\sigma_2 < 0$) is compressing.

A wide range of opportunities for application of soft covers is due to a number of their advantages. They are light in weight, compact in the folded state, easy to produce, install and dismantle, have good maneuverability in operating time and high seismic resistance. Professor V.A. Volosukhin contributed greatly into development of the technical theory of soft fabric structures (SFS), among others under long movements and deformations [13-18].

Composite cloth AGM-Kompozit, unites properties of nonwoven fabrics and woven geotextiles. Nonwoven geotextiles possess the excellent draining and filtering capacities. These geotextiles are applied as filters in drainage designs. Geocomposite material AGM-Kompozit is produced by a method of knitting. It represents connection of a foundation geogrid from high-strength polyester threads and a nonwoven geotextile cloth from polyester or propylene. Such geocomposite material has high tensile strength and breakdown, at the same time keeps all advantages of nonwoven fabric (filtration, drainage, layer division) (fig.3).

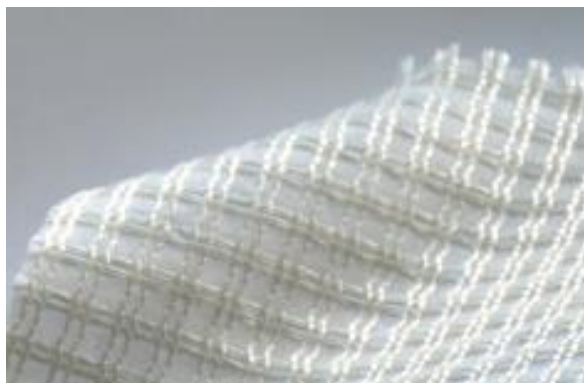


Figure 3. Composite cloth AGM-Kompozit.

Using of soft materials is the most perspective due to the following factors:

- these structures are characterized by light weight, mobility, compactness in folded form, are installed and dismantled in short terms and easy to transport;
- separate structure elements can be replaced if required;
- these structures have the small level of resource intensity that provides the high level of environmental compatibility;
- soft structures allow to control water quality on water bodies.

All means of hydrotechnical support have validity period (operation, efficiency) which is connected with limited service life of the used constructions (concrete, reinforced concrete, metal), reduction of their efficiency eventually. Making decisions on the use of means of hydrotechnical support it is necessary to estimate the consequences connected with their limited operation term as high as possible. Assessment of efficiency has to be made when choosing technical solutions, determining degree of danger of the planned works and possibility of emergency on a water body.

Indisputable advantages of soft fabric structures, when using in water management are:

- lack of corrosion;
- fineness and lightness of a structure;
- possibility to create irregular shapes;
- simplicity of installation and dismantling;
- profitability of cloth washing;
- durability of the structure operated in water environment.

2. Conclusion

Installation of the proposed structure solves problems of slush, plankton, suspended particles control economically. Moreover, clearer water will get to a watershed because the high-strength fabric structure works as a filter, holding large and small litter, without demanding high costs for cleaning and washing.

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