

Problems of Irrigation Canals and Modern Methods of Their Technical Improvement due to Innovative Concrete Materials and Technologies

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Abstract – The article presents the current problems of irrigation canals. A statistical analysis of data on the status of irrigation canals in the Saratov region has been carried out. The problematic aspects of the irrigation network, on which work is needed, are noted. The main types of water loss from the irrigation network are substantiated. The areas of the greatest losses of water resources from the irrigation network and temporary irrigators were determined. The negative consequences of the loss of water resources from the irrigation network are substantiated. The question was raised about the technical re-equipment of irrigation canals, due to the incompatibility of current materials with the norms and regulations. An innovative concrete material is proposed that solves the main problems of irrigation canals. A comparative analysis of the advantages of a concrete web over concrete facing plates for covering irrigation canals was carried out. An optimal method for the formation of concrete materials when covering irrigation canals is proposed. The predicted benefits of using this method are described.

Keywords – land reclamation; irrigation canals; irrigation systems; irrigation network; construction and reconstruction; construction materials.

I. INTRODUCTION

The irrigation canal is the main transport element of the irrigation network, which is responsible for the supply of irrigation water from the time it is taken and until it is used for its intended purpose in the irrigated area.

The ameliorative fund of the Saratov region is one of the largest in Russia, having a huge network of canals, while the condition of 30% of irrigation canals has serious technical problems associated with physical and moral condition.

The purpose of this article is to consider the problems of irrigation canals and, accordingly, to bring modern ways of their technical improvement through innovative concrete materials and technologies in the Saratov region.

The problem of re-equipment of irrigation canals is relevant, since a large number of irrigation canals in Russia need re-equipment and reconstruction.

II. METHODS AND MATERIALS

In conducting the study, empirical cognition was used, which served as a synthesis for the theoretical analysis of the literature by the deductive method. The theoretical method included the summarization, note-taking and quoting of general and special scientific works of scientists in this high-tech area. In the work, mathematical and statistical methods were used to obtain and establish quantitative dependencies between the studied phenomena. The mathematical method included data logging. The statistical method included the determination of the average values of the obtained indicators, respectively, comparing and obtaining the quantitative or qualitative dependence of the process under study.

III. RESULTS

According to the FSBI "Management" Saratovmeliovodhoz", the permanent irrigation network includes 1,205.5 kilometers of open irrigation canals, of which 46.8 in the earthen channel and 53.2 in the lined (see table 1).

With the existing large extent of the irrigation network, there are serious problems with the state of 30% of the entire permanent network of open irrigation canals. These problems include:

1. Low efficiency (average efficiency of 70%) of irrigation canals;
2. Loss of water resources (infiltration);
3. Physical and moral deterioration of irrigation canals [1, 8].

The problems described above signal low hydraulic efficiency and large losses of irrigation water, which subsequently exceeds the norms of SP 81.13330.2017 by 15-20%.

An analysis of the literature on our research helped to form a general idea of the loss of water resources from the irrigation network. Imagine the total loss of water from the irrigation

canal for 100% and, accordingly, we determine the loss as a percentage for infiltration, technical loss and evaporation (see Figure 1) [6].

TABLE I. ANALYSIS OF THE STATE OF THE IRRIGATION NETWORK OF THE SARATOV REGION ON 01/01/2019

The name of indicators	Unit of measurement	Amount	Requires recovery %
Permanent irrigation network total:	km	5887,3	81,5
Including channels:	km	1205,5	30*
Of them:			
in lined bed:	km	821	35*
in the earthen channel:	km	384,5	30*

^a. Note: * - approximate variable value

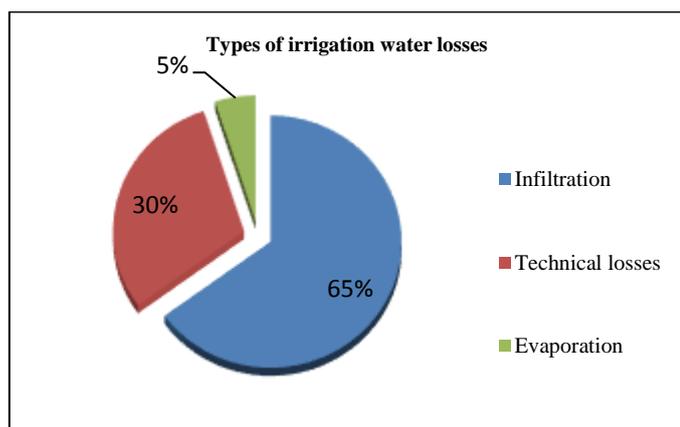


Fig. 1. Total loss of irrigation water from the irrigation network

As Figure 1 shows, the majority of water loss from the irrigation network is due to infiltration, this aspect should be given special attention.

For more informative, the total amount of water loss of the irrigation network can be distributed to the plots as a percentage (see Figure 1) [6].

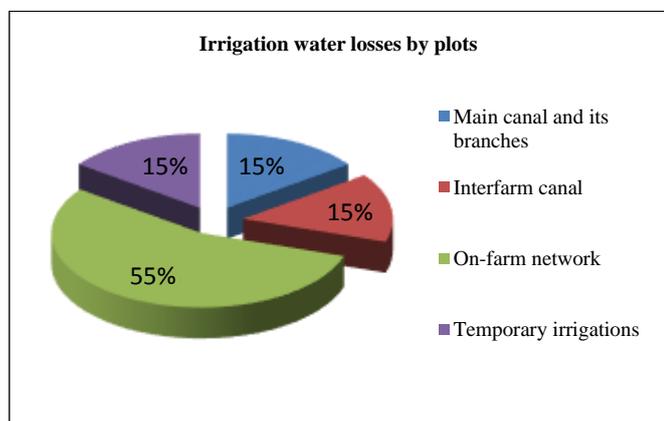


Fig. 2. Total water loss in the irrigation network

From Figure 2 it follows that the main losses fall on the on-farm network. This situation is explained by the fact that the main and inter-farm channels have an impervious lining, and the on-farm network in most cases has an earth bed.

In the works of V. Olgarenko, G.V. Olgarenko, V.N. Rybkina, Yu.M. Kosichenko, O. Baeva, A. Ishchenko well represented filter losses from the channel and their consequences:

- Unproductive water losses lead to a decrease in the efficiency of the irrigation network;
- Rising groundwater levels necessitates the construction of drainage and drainage drainage;
- Flooding, waterlogging and soil salinization lead to the unsuitability of agricultural land [4, 7].

Based on the foregoing, it is possible to express the general idea that when one or several canals fail, certain irrigated areas will not receive water or will receive, but in small quantities, which will adversely affect the yield and return of agricultural products from 1 hectare.

The current situation requires the adoption of measures for the rehabilitation and stable functioning of irrigation canals. It is worth noting that concrete impervious claddings become ineffective and need to be replaced, since they cannot provide the required minimum level of infiltration [3, 4, 5].

We propose to use an innovative material – concrete canvas. This material can solve existing problems, as well as increase the efficiency of the irrigation network (with full network renewal) to 0.90-0.95, since it completely eliminates water loss in canals covered with canvas due to complete sealing.

All the advantages of this material can be seen in Table 2. This analysis was carried out in comparison with concrete lining. The presented comparison reflects all the advantages of the material. In this table, the analysis was carried out using a concrete sheet of the CC8 brand and a brand of concrete slabs PK-30-25 with a dimension of 3000x2500x80 [2].

TABLE II. CONCRETE LINING

Indicator	Concrete canvas	Concrete lining
Cost, rubles	1m ² = 3000	1m ² = 4000
Weight, kg	1m ² = 10	1m ² = 200
Availability of equipment, (minimum, maximum)	Minimum	Maximum
Availability of specialized workers, (minimum, maximum)	Minimum	Maximum
Availability of necessary equipment, (minimum, maximum)	Minimum	Maximum
Laying speed, m ² / day	800	80
Acquisition of the necessary strength, hours	24	72
The seriousness of the preparation for the work, (minimum, maximum)	Minimum	Maximum
Logistics level for delivery (low, medium, high)	Low	High
Crack resistance, (low, medium, high)	High	Medium
Environmentally friendly, (needs disposal of waste, does not need)	Does not need	Needs
Water resistant, (absent, low, medium, high)	Absent	Medium
Frost resistance, (low, medium, high)	High	Medium
Compressive strength, (low, medium, high)	High	High
Flexural strength (low, medium, high)	Medium	High

Based on the data in Table 2, we get the following: high strength, full waterproofing, long service life, environmental friendliness, lightness of the material and ease of installation.

The lightness of the material and ease of installation is justified by the fact that when working on laying a concrete leaf in the earthen channel, you need to have: concrete canvas, working clothing, office knife, circular saw, metal stakes, hammer, automatic screwdriver and stainless steel screws, construction sealant. You also need the help of 1-2 excavators to create anchor grooves and a crane when using concrete web in large rolls.

When channeling concrete, the situation is more complicated, since the construction process may include the delivery of ready-mixed concrete, the delivery of ready-made concrete slabs or the preparation of concrete at the work site. Concrete does not have the ease and compactness, on the basis of this logistics costs will be much higher.

At the same time, we recommend using the method developed by us for choosing the most rational concrete canvas for a specific irrigation canal.

The proposed method for the formation of concrete material to cover irrigation canals involves determining the optimal dimensions and characteristics through technical and economic calculations that will allow you to correctly form sets of concrete materials for each type of canals.

The initial data are: concrete materials, irrigation canals of the irrigation network, the planned amount of work at each facility, the planned hourly operational productivity of workers and machines at each facility and the cost of the concrete web.

The duration of the work of machines at each facility (X_{ij} , mash-h) is determined by the formula:

$$X_{mij} = V_j / \Pi_{\text{э}ij}; \quad (1)$$

where V_j - the amount of work on the j- object; $\Pi_{\text{э}ij}$ - hourly operational productivity of the machine of the i- type on the j- object.

The duration of the work of workers at each facility (X_{ij} , man-hours) is determined by the formula:

$$X_{\text{ч}ij} = V_j / P_{\text{э}ij}; \quad (2)$$

where V_j - the amount of work on the j-object; $\Pi_{\text{э}ij}$ - hourly operational productivity of a worker at the j- object.

The calculation of the working hours of workers and machines is made taking into account the full implementation of the scope of work. It is also necessary to introduce a restriction that takes into account the timely execution of work in accordance with the working time fund:

$$X_{\text{ч}ij} \leq \Phi_i; \quad X_{mij} \leq \Phi_i; \quad (3)$$

where Φ_i is the working time fund of the i-machine and the working time fund of the i-working day.

If condition (3) is not met, then the corresponding position is excluded from consideration.

Since the concrete canvas reduces the construction process several times and excludes construction equipment during excavation work, it is obvious that using concrete concrete, the works will be completed on time.

To assess the effectiveness of the use of concrete canvases at the facilities, the reduced costs are calculated according to the formula:

$$Z_{nij} = C_{\text{м.ч.}ij} * C_{\text{п.ч.}ij} * (X_{\text{ч}ij} * X_{mij}) + C_{\text{мат.общ}} \quad (4)$$

where Z_{nij} - reduced costs when using concrete material i-size on the j-object; $C_{\text{м.ч.}ij}$ - cost of 1 machine. work i - destination on the j-object; $C_{\text{п.ч.}ij}$ - cost of labor. work i-th destination on the j-object; $C_{\text{мат.общ}}$ -cost of concrete material i-size.

The calculations in the table are as follows. First, known values and estimated indicators are recorded, respectively. Vertically recorded names of irrigation canals and horizontally variants of concrete canvases. Then, the reduced costs for each cell are calculated by the formula (4) and the values obtained are entered in a table. Then among the values of each column (respectively, each concrete material) is the minimum value of the reduced cost Z_{nij} , and one is written into the cell corresponding to $Z_{nij} = \min$, and the remaining zero. Further, according to each irrigation canal, a threshold of maximum costs for a concrete web will be established and there will be a comparison of the material cost and the max of possible costs, if these costs meet the stated requirements, a unit is written, the remaining zero. The final step in the calculation is to determine the priority number.

$Z_{\text{пп}}$, which is the summation of the rows written in the cells of the calculation table of zeros and ones.

The working time fund should be taken into account when comparing materials of different nature of origin, such as concrete web and concrete slabs. In this case, the accounting of the fund of working time is necessary, and it is added to each cell.

The hourly productivity of machines $\Pi_{\text{э}ij}$ should be taken into account if there is at least one option where the equipment is necessary. In this case, accounting is required.

It is worth noting that this method is very versatile and can include or exclude the required indicators pursued in a particular study.

The most optimal is the version of the concrete canvas, which has a greater value of the priority number. Moreover, the greater the number of irrigation canals, the higher the reliability of the conclusion about the effectiveness of a particular variant of the concrete canvas. When identifying materials with the same amount of priority, additional selection criteria are

introduced or one of the n-th variant of the final materials is chosen to cover irrigation canals according to more attractive parameters.

The quality of materials and total costs are the main criteria.

For convenience of calculation and clarity, the calculation is performed in the form of the table below.

TABLE III. DETERMINATION OF THE OPTIMAL SIZE OF CONCRETE CANVAS FOR IRRIGATION CANALS

irrigation canals	Concrete material						Priority number Z_{np}
	V1	V2	...	Vj	...	Vn	
1	$3_{n11}C_{m.o.11}$	$3_{n12}C_{m.o.12}$	...	$3_{n1j}C_{m.o.1j}$	...	$3_{n1n}C_{m.o.1n}$	Z_{np1}
2	$3_{n21}C_{m.o.21}$	$3_{n22}C_{m.o.22}$	...	$3_{n2j}C_{m.o.2j}$	...	$3_{n2n}C_{m.o.2n}$	Z_{np2}
3	$3_{n31}C_{m.o.31}$	$3_{n32}C_{m.o.32}$	...	$3_{n3j}C_{m.o.3j}$	...	$3_{n3n}C_{m.o.3n}$	Z_{np3}
...
i	$3_{ni1}C_{m.o.i1}$	$3_{ni2}C_{m.o.i2}$	...	$3_{nij}C_{m.o.ij}$	...	$3_{nin}C_{m.o.in}$	Z_{npi}
...
m	$3_{nm1}C_{m.o.m1}$	$3_{nm2}C_{m.o.m2}$	...	$3_{nmj}C_{m.o.mj}$	...	$3_{nmn}C_{m.o.mn}$	Z_{npm}

The concrete material proposed by us and the method of its rational approach can provide an increase in the hydraulic efficiency and operational reliability of irrigation canals. Also, these measures respectively increase the efficiency of irrigation canals to the maximum possible indicators, depending on the initial state. It is necessary to consider that there are irreversible losses of water from evaporation, this fact cannot be avoided, it can only be reduced due to the uninterrupted and long-term operation of the channel.

IV. CONCLUSION

The problems considered in the article have many solutions, in this article we considered several rational options. Research

into the status of irrigation canals makes it clear that the current state of the irrigation network does not meet modern requirements and requires a new approach.

Thus, we have considered the problems of irrigation canals and presented an effective way to improve them through an innovative concrete material and the method of their rational selection. This method will allow to rationally select the material according to the means and individual characteristics of the channel, while it will serve as a good theoretical and practical basis for further research in this area of science.

Scientific progress and breakthrough developments determine success in a particular field of science. It follows that it is impossible to dwell on the achievements of the past and it is necessary to keep up with the times, in this case it concerns innovative materials, methods and technologies for land reclamation.

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