Filtration reliability of the channel with concrete lining

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Abstract. The article considers the filtration reliability of the Bustan canal with a concrete lining in the southern part of the Republic of Karakalpakstan. The purpose of the reconstruction of the canal is to avoid the pumped irrigation and the high water consumption associated with it, and change to gravity irrigation with increased efficiency through the implementation of reliable waterproofing measures.In addition, to provide irrigation water to command areas of 100 thousand hectares, Ellikal'a, Beruni and Turtkul regions, the canal is constructed in the fill,partially semi-excavation and semi-fill. The canal is located in the sandy areas and,accordingly the embankment is constructed using sandy material with layer-by-layer compaction to achieve a density of 1.66 g/cm3. Concrete class B25 with thickness 12cm, was laid on geotextile and geomembrane 1.5 mm thick. The main objective of the field research of the constructed section was to check water tightness and durability of the work completed.The field investigationswere carried out on two experimental sections of the Bustan canal in 50 m length, from PK47 + 55 to PK 48 + 00 and from PK 266 + 37 to 265 + 87. Here are results of investigation on the first experimental section which were carried out from 12/15/2021 to 12/21/2021 for 7 days. During the seven days, observations were made of leakage along the side embankments, outer slope of the canal embankments, and evaporation from the surface of ponding canal section was also measured. Evaporation of water during this time was3.5 mm/day, i.e., the water level in the experimental section was decreased only due to the loss of evaporation. During the observation period, leakage of water was not observed, which indicates sufficient reliability of water tightness, concrete lining and geomembrane.

1 Introduction

Filtration reliability is an important factor in determining the efficiency of irrigation systems[1].

In researches[2,3], general methods for assessing the reliability of a filtration system in soil structures are considered. Irrigation canals are not considered here.

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The researches [4–6] present the results of studies of non-stationary filtration in soil dams and canals.

Article [7,8] describes the main geosynthetic materials used in hydraulic engineering construction. In the studies of the authors [9], the issues of reconstruction of an irrigation canal in Indonesia with various types of linings are considered: brick, prefabricated slabs and concrete. It is noted that the best option is concrete lining. In [10–12], the water tightness and efficiency of waterproofing elements of various structuresfor large canals were estimated. The article [13] analyzes the work on the water losses from canalsin the USA.

In [14], the options for canal linings with a geomembrane are considered, as well as methods for their filtration calculation.

In the researches [15–20] the issues of seepage from the earthcanals and with lining, methods of their calculation, modern methods of control and operational reliability of structures were considered.

In the monograph [20] and in the article [21–24]consider the effectiveness and durability of canal linings with geosynthetic materials: polymeric geomembranes and bentomats. The effectiveness of the variant with bentomats has been considered.

In the article [25], the mechanism of damage to concrete linings from frost heaving of the soil is revealed and methods are given to solvethese issues.

Article [26] describes a method for calculating evaporation from a water surface, including a polluted one.

In our article [27], we present the results of field investigationfor the water tightness of concrete lining on the Bustan canal between PK 266+37 to PK 265+87.

This article presents the results of the second full-scale experiment carried out on the same canal between PK 47+55 to PK 50+00.

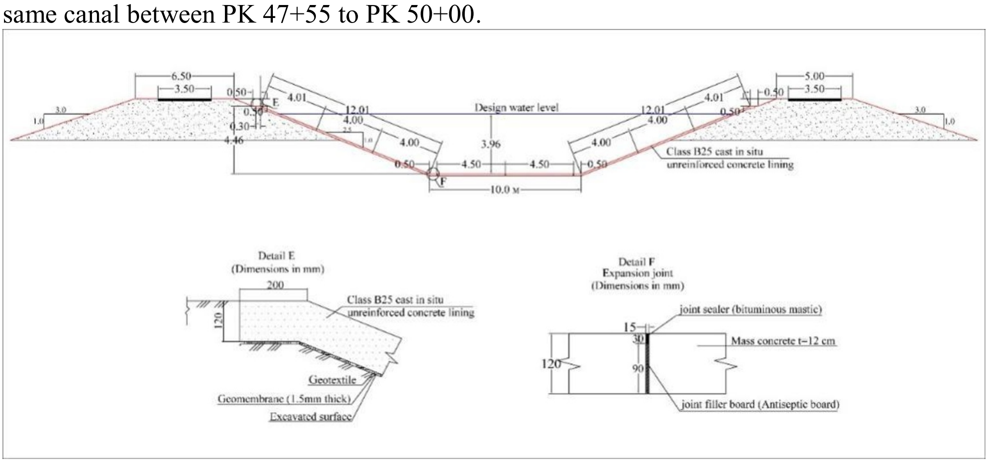

Fig. 1. Typical cross section of Buston canal

The conditions in this case are different in that the experiment were carried out in winter season and the canal pass through semi-excavation and semi-fill[28–31].

The task of the field investigation includes: preparation of the experimental site, observations of wind speed, air humidity, water and ambient air temperatures, surveying the water level 3 times a day, and monitoring a filtration [32–34].

The embankment was constructedusing sandy material layer-by-layer with a thickness of 30 cm at an optimum moisture content of 12-14% to achieve a design density of 1.66 g/cm^3. The density of the soil on each layer of the site was checked using a density-moisture meter of engineer N.P. Kovalev with Vasiliev's balancing cone. A geomembrane HDPE-1.1.5 with a thickness of 1.5 mm was laid. Tensile strength in longitudinal direction

19.8 MPa (19800 kN/m^2) in transverse direction 31.6 MPa (31600 kN/m^2) elongation at break 940%. A fibric needle-punched non-woven geotextile weight at least 250 g/m^2 was installed above the geomembrane (Fig. 2). Seamwas performed by melting with a LT 900 device. Concrete class B25 with 12 cm thick was placed using a concrete lining machine[28,35].

Fig. 2. Placement of concrete on the canal slope over the geotextile/geomembrane

2 Methods

A section of the eastern part of Bustan canal from PK 47+55 to PK 48+00 with a length of 45 m was selected for carrying out field experiment. The plan of the experimental section is shown in Fig.3.

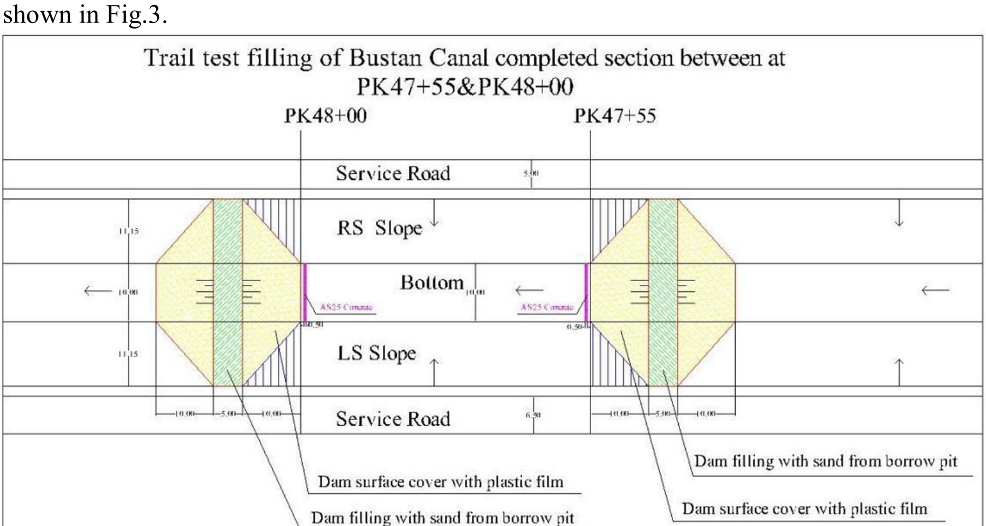

Fig. 3. Plan of experimentalcanalsection PK47+55 to PK48+00.

Fig. 4. Plan of experimentalcanalsection PK47+55 to PK48+00.

The canal was blocked on both sides by an earth temporary dam and, geocompositewas covered to prevent seepage from the pool (Fig. 4).

Observations were made on water leaks and filtration. Leakage through the canal embankment is possible if the geomembrane has not been properly laid or has been punctured, the quality of the concrete is poor, the seams of the geomembrane are in poor quality, or the joints between the concrete lining are not sealed.

Water levels in the experimental area were measured 3 times a day using a levelling machine (Fig. 5). The weather conditions were taken according to the data of the Turtkul meteorological station: wind speed, air temperature and humidity. The water temperature was measured using a WT-1 digital thermometer with a stainless-steel needle probe with a plastic handle, which has a built-in liquid crystal display (Fig. 6).

Fig. 5. Checking the water level

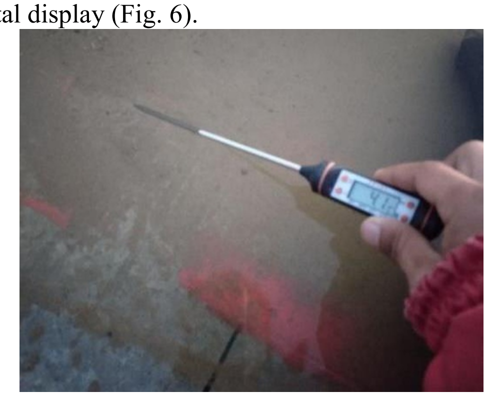

Fig. 6. Checking the water temperature

Filling with water was carried out using pumps up to the maximum water level in the canal.

3 Results and Discussion

The observations were carried out for 7 days from December 15 to December 21, 2021. During these days, no water leakage, seepage or wet spots were detected along the entire outer perimeter of the canal and dams. This means that the quality of concrete lining, geomembrane, geotextile meets the requirements of the design. Filtration reliability of the experimental section is ensured and remains effective against filtration .

Decrease of water level has been observed. Therefore, calculations of evaporation from the water surface were carried out according to the existing formula of V.D. Zaikov [36].

$$H_{evp} = 11{,}6 \cdot (E_1 - e0) \cdot B \cdot t / 30 \tag{1}$$

Where:

H_{evp} - evaporation layer in the water storage per day in mm;

11.6 - coefficient taking into account the specific suction atmosphere in mm / millibar month;

E_1 - maximum elasticity of water vapor at a given temperature of the water surface in millibars;

The partial pressure of water vapor in air is determined by the formula:

$$e_0 = \mu \cdot E_1 / 100 \tag{2}$$

μ - relative air humidity in%.

B - coefficient taking into account the strength of the wind;

$$B = 1 + 0{,}134 V_v \tag{3}$$

V_v - average wind speed in m/s (per month);

t is the estimated evaporation time, measured in days.

The data of observations and calculations for evaporation are given in Table 1.

Observation and calculation data for evaporation at the experimental section

Table 1. Observation and calculation data for evaporation at the experimental section

№	Date	Chesk time	Temperature Of Water Surface	Atmospheric Pressre (Kpa)	Relative Humidity	Wind Speed	Evaportrion (mm/d)	Average Evaportion Speed (mm/d)	Actual Evaportion Speed (mm/d)	Average Actual Evaportion Speed (mm/d)
1	15/12/2021	7:58	3	103·90	99%	5	0.60		0.5	
2	15/12/2021	16:41	4.5	103·70	71%	7	2.20	1·24	1.8	1
3	15/12/2021	21:57	4.3	103·70	86%	6	0.91		0.8	
4	16/12/2021	8:27	4.4	103.20	86%	5	0.77		0.4	
5	16/12/2021	14:32	5.2	103.30	69%	8	2.89	1.50	2.8	1.2
6	16/12/2021	20:08	4.1	102.60	87%	6	0.83		0.4	
7	17/12/2021	8:01	4.5	102.20	60%	6	2.63		2.4	
8	17/12/2021	14:35	10.5	102.50	38%	8	8.03	5.64	7.8	5.4
9	17/12/2021	19:12	7.8	102.70	42%	8	6.26		6.0	
10	18/12/2021	8:12	3.9	101.50	63%	4	1.63		1.4	
11	18/12/2021	16:23	11.2	101.10	35%	8	8.81	4.55	8.3	4.3
12	18/12/2021	20:17	5.1	101.10	53%	6	3.21		3.0	

13	19/12/2021	8:03	405	101.10	59%	5	2.28	3.95	2.0	3.7
14	19/12/2021	14:19	12.1	101.40	43%	6	6.27		6.1	
15	19/12/2021	18:12	6.1	101.40	55%	6	3.30		3.1	
16	20/12/2021	7:57	4.1	101.30	57%	5	2.33	5.15	2.1	4.93
17	20/12/2021	13:24	13.7	101.10	36%	7	9.02		8.9	
18	20/12/2021	17:38	6.5	101.60	53%	7	4.09		3.8	
19	21/12/2021	8:12	5.2	100.70	70%	7	2.39	4.56	2.0	4.3
20	21/12/2021	13:04	11.0	100.30	43%	7	6.72		6.5	
21	21/12/2021	17:23	5.3	100.60	55%	9	4.58		4.3	

It can be seen from the table, the average evaporation rates calculated and measured are close to each other. The water level in the canal has been decreased due to the loss of evaporation, the weather data observed daily for the calculation of evaporation has been shown in the table1.

The average loss due to evaporation was calculated to be 4 mm/day and measured in nature 3,5 mm/day.

4 Conclusions

- The results of the observations shows that the quality of the work performed is satisfactory andthe filtration reliability of the canal lining is ensured.
- The water level in the experimental sectionhas been decreasedonly due to evaporation, depending on the temperature and humidity of the air, wind speed and is 4 mm/day according to calculations and 3.5 mm/day according to field data.

References

1. D. L. Bjorneberg, in *Ref. Modul. Earth Syst. Environ. Sci.* (Elsevier, 2013)
2. D. Sobarna, Semin. Teknol. MAJALENGKA **6**, 264 (2022)
3. N. Belendir, A. Ivashintsov, and D. Stefanyshyn, *Methods for Assessing the Reliability of Soil Hydraulic Structures.* (2004)
4. M. Bakiev, S. Djabbarova, and U. Masharipov, Irrig. Melior. **Special issue**, 85 (2018)
5. K. Fayziev, S. Baytmatov, and K. Juraev, Int. J. Adv. Sci. Technol. **29**, 3006 (2020)
6. K. Fayziev and K. Juraev, Int. J. Adv. Res. Sci. Eng. Technol. **6**, (2019)
7. O. I. Gladshtein, Hydrotechnics **1**, 14 (2009)
8. I. A. Weerasinghe, C. Gallage, and L. Dawes, Heliyon **7**, e05770 (2021)
9. P. Iskandar, P. Dinar Dwi Anugerah, and W. Putri Kusuma, Int. J. Adv. Technol. Eng. Explor. **8**, 576 (2021)
10. M. Waldvogel, R. Zurbriggen, N. Toropovs, A. Berger, and M. Herwegh, Cem. Concr. Compos. **138**, 104982 (2023)
11. Y. Jiang, B. He, J. Zhao, H. Pei, J. Liu, and H. Wang, Constr. Build. Mater. **360**, 129579 (2022)
12. A. V. Ishchenko, *Hydraulic Model of Water Tightness and Efficiency of Water Proofingfor Large Canals.* (2010)
13. P. I. Kovalenko, L. Reclam. Water Manag. **3**, 57 (1991)
14. A. V. Kolganov, Y. M. Kosichenko, and E. O. Sklyarenko, L. Reclam. Hydraul. Eng. (2022)

15. Y. M. Kosichenko, *Canals for the Discharge of Flow in Russia.* (2004)
16. Y. M. Kosichenko, in *News High. Educ. Institutions. North Cauc. Reg. Ser. Eng. Sci.* (2014), pp. 68–74
17. Y. . Kosichenko, L. Reclam. Water Manag. **6**, 24 (2006)
18. Y. M. Kosichenko, O. A. Bae, and A. V. Ishchenko, Eng. Bull. Don **3**, 13 (2014)
19. Y. M. Kosichenko, Sci. J. Russ. Res. Inst. L. Reclam. Probl. Ros RILRP **2**, 9 (2012)
20. Y. M. Kosichenko and O. A. Baev, *Anti-Filtration Coatings from Geosynthetic Materials: Monograph.* (2014)
21. Y. M. Kosichenko and O. Baev, Mag. Civ. Eng. (2020)
22. M. A. Chernov, Sci. J. Russ. Res. Inst. L. Reclam. Probl. **13**, 13 (2011)
23. M. A. Chernov, North Cauc. Reg. Ser. Eng. Sci. **2**, 108 (2011)
24. M. A. Chernov, Anti-Filtration Structures of Canals and Reservoirs Using Geomembranes Made of High-Low-Pressure Polyethylene:, 2011
25. J. Li, X. He, and B. Zhou, J. Coast. Res. **93**, 264 (2019)
26. L. . Miroshnichenko, Y. O. Grigoriev, S. Y. Shishmakov, N. V. Sluzhenikina, O. B. Naschetnikova, and A. F. Nikiforov, Water Sect. Russ. Probl. Technol. Manag. (2017)
27. B. P. Kulumbetov, M. R. Bakiev, K. T. Yakubov, and Z. U. Uzakov, J. Agroprocessing. **5**, (2023)
28. A. Yangiev, A. Ashrabov, and O. Muratov, in *E3S Web Conf.* (2019)
29. A. Yangiev, S. Eshev, S. Panjiev, and A. Rakhimov, in *IOP Conf. Ser. Mater. Sci. Eng.* (2020)
30. A. Yangiev, G. Omarova, F. Yunusova, D. Adjimuratov, and A. Risalieva, E3S Web Conf. **264**, 03014 (2021)
31. O. Kadirov and K. Khasanov, in *E3S Web Conf.* (2023)
32. A. Khalimbetov, M. Bakiev, S. Shukurova, J. Choriev, and K. Khayitov, in *IOP Conf. Ser. Earth Environ. Sci.*, edited by T. O. (IOP Publishing Ltd, 2020)
33. M. Bakiev, U. Kaxxarov, A. Jakhonov, and O. Matkarimov, in *IOP Conf. Ser. Mater. Sci. Eng.* (2020)
34. M. Bakiev, K. Yakubov, and J. Choriev, in *IOP Conf. Ser. Mater. Sci. Eng.* (IOP Publishing Ltd, 2020)
35. A. Yangiev, D. Adjimuratov, F. Gapparov, and F. Yunusova, in *IOP Conf. Ser. Mater. Sci. Eng.* (2020)
36. B. Zaikov, *Evaporation from the Water Surface of Ponds and Small Reservoirs on the Territory of the USSR* (2011)