TECHNOLOGICAL AND ENGINEERING-GEOLOGICAL APPROACHES TO THE RECONSTRUCTION OF THE QUMDARYO FLOOD DIVERSION CANAL

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Abstract: This article analyzes the current condition of the Qumdaryo flood diversion canal located in Chiroqchi District of the Kashkadarya Region, as well as the natural, geomorphological, hydrogeological, and soil conditions of the area. The research findings revealed significant deterioration of the canal's concrete lining, a reduction in its water conveyance capacity, and an increased risk of flood and mudflow events. The physical and mechanical properties of the soils and the groundwater regime were thoroughly investigated. Based on the study results, the reconstruction of a 0.5-km section of the canal and the construction of a rapid-flow spillway structure are recommended. The proposed measures will contribute to reducing flood and mudflow hazards and improving water supply conditions for approximately 800 hectares of irrigated agricultural land.

Keywords: Qumdaryo flood diversion canal, hydrogeological conditions, soil properties, mudflow and flood hazards, irrigation, reconstruction, land reclamation (melioration), water conveyance capacity.

Аннотация: В статье анализируется текущее состояние водоотводного канала Кумдарьо, расположенного в Чиракчинском районе Кашкадарьинской области, природные, геоморфологические, гидрогеологические и почвенные условия местности. В результате исследований выявлено ухудшение состояния бетонной облицовки канала, снижение его водопроницаемости и увеличение риска затопления. Изучены физико-механические свойства грунтов и режим грунтовых вод. В рамках проекта рекомендуется реконструировать участок канала длиной 0,5 км и построить быстроходный водопад. Эти меры позволят снизить риск затопления и улучшить водоснабжение около 800 гектаров орошаемых земель.

Ключевые слова: Паводковое русло реки Кумдарьо, гидрогеологические условия, свойства грунта, наводнения, орошение, реконструкция, мелиорация земель, водоносная способность.

The Qumdaryo flood diversion canal, located in the Kashkadarya Region, was constructed in 1971 and has a total length of 0.8 km. At present, approximately 500 m of the canal is lined with concrete, while the remaining section has been subjected to severe erosion and gully formation due to the impact of mudflow and floodwaters. The existing hydraulic structure has become technologically obsolete, and its water conveyance capacity is limited to 65 m^3/s. The area is characterized by a slightly undulating alluvial–proluvial plain, where the hydrogeological properties of soils and groundwater play a significant role in the operation of irrigation systems. Climatic conditions are characterized by aridity, low precipitation, and high evaporation rates. The physical and mechanical properties of soils, as well as their filtration characteristics, constitute the basis for the design of engineering measures. Therefore, reconstruction of the canal and mitigation of mudflow and flood hazards represent important engineering challenges.

The project area is situated on the right bank of the Kashkadarya River within an alluvial–proluvial plain belonging to a second-order geomorphological unit. The terrain is slightly undulating and gently slopes westward toward the river valley. Absolute elevations range from 570 to 650 m above sea level. The irrigated lands are located within the southern semi-desert climatic zone of Central Asia and are characterized by a sharply continental and arid climate. The average annual air temperature is 15.6 °C, while the average summer temperature reaches 28.3 °C. Winters are short and relatively snowless, whereas summers are long, hot, and dry. The mean annual precipitation amounts to 369.6 mm, annual evaporation reaches 1477.1 mm, and relative humidity averages 59%. The mean wind speed is 2.6 m/s, with winds exceeding 15 m/s occurring on up to 13 days per year. These climatic conditions make rain-fed agriculture impractical and intensify physical weathering and soil salinization processes.

Geomorphological and Lithological Conditions

The engineering-geological assessment of the area was based on investigations conducted at the “Beshchashma” and “Oqchova” sites in Chiroqchi District. The geological profile to a depth of 50 m consists mainly of Upper Quaternary loess-like yellowish-gray macro-porous alluvial–proluvial deposits with a thickness exceeding 50 m. A single groundwater-bearing horizon, mainly within sandy deposits, was identified. Groundwater is recharged by subsurface inflow, irrigation water infiltration, and precipitation, and flows toward the river channel.

Groundwater occurs at depths of 3.8–13.45 m, with mineralization ranging from 1.5 to 2.0 g/L and a sulfate–hydrocarbonate calcium–magnesium composition. Its regime is irrigation-dependent, showing seasonal fluctuations of 1.5–3.5 m, with higher levels during the growing season and lower levels in winter. New irrigation activities are not expected to cause a significant rise in groundwater levels.

The soils belong to subsidence Types I and II, with potential settlements of up to 0.05 m and 0.30 m, respectively. The area has a seismicity rating of 7 points. Therefore, irrigation and drainage systems should include anti-subsidence measures, prevent uncontrolled water losses, and maintain permissible flow velocities.

Hydrogeological Conditions

The hydrogeological conditions of the study area are influenced by climatic, geomorphological-lithological, and water-management factors. Within the investigated profile to a depth of 50 m, a single Quaternary aquifer was identified, consisting mainly of sandy and dense light-gray soils.

Pumping tests at depths of 7–28 m showed well yields of 2.67–5.7 L/s and filtration coefficients of 10.2–10.5 m/day. Groundwater mineralization ranges from 1.0 to 3.2 g/L, with sulfate-dominated chemical compositions.

Groundwater recharge occurs through seepage from irrigation systems and precipitation infiltration, while discharge takes place through subsurface flow, evaporation, and plant transpiration. Groundwater levels remain relatively stable, with annual fluctuations of 0.5–1.0 m. Expansion of irrigated areas may increase groundwater levels by 0.5–1.5 m annually and contribute to the growth of groundwater reserves.

Engineering-Geological Assessment of the Reconstruction Project

The project involves the reconstruction of the flood diversion canal at PK177+30 of the Qumdaryo Canal in Chiroqchi District, including rehabilitation of a 0.5 km canal section and construction of a rapid-flow drop structure at PK5+00. The objective is to safely convey flood and mudflow waters and improve irrigation water supply for about 800 ha of agricultural land.

Engineering-geological investigations, based on archival and laboratory data, identified four engineering-geological soil units. The area is mainly composed of sandy and sandy-loam soils with satisfactory physical and mechanical properties for hydraulic construction. The soils exhibit dense upper layers, plastic consistency below groundwater level, and widespread macro-porosity.

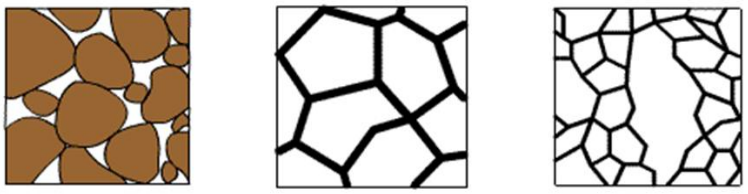

Table 1.1

Standard Values of Cohesion and Internal Friction Angle

№	Parameters	Unit	Engineering-Geological Elements	
			Sandy loam	Loam
1	**Mechanical Composition of Particle-Size Fractions, mm** 1,0-0,5 0,5-0,25 0,25-0,1 0,1-0,05 0,05-0,01 0,01-0,005 menee 0,005	% % % % % % % %	 0,3 0,6 0,8 11,5 47,1 27,5 12,5	 - 2,4 1,6 8,1 25,6 34,8 27,5
2	**Atterberg Limits:** a) **Liquid Limit (LL)** b) **Plastic Limit (PL)** c) **Plasticity Index (PI)**	 % % %	 27 22 5	 30,2 20,5 9,7
3	Density: Particle Density Bulk Density Dry Density (Soil Skeleton Density)	 t/m^3 t/m^3 t/m^3	 2,7 1,54 1,38	 2,71 1,55 1,33
4	Density	%	49,0	50,9
5	Density Coefficient (Void Ratio)	–	0.963	1.037
6	Natural Moisture Content	%	18.78	16.63
7	Standard Deviation of Cohesion	–	0.013	0.011
8	Cohesion	kg/cm^2	0.03	0.07
9	Internal Friction Angle	degree	27	24
10a	Deformation Modulus (Water-Saturated Condition)	kg/cm^2	20–30	25

10b	Deformation Modulus (Natural Condition)	kg/cm²	140	120
11a	Design Resistance (Water-Saturated Condition)	kg/cm²	1.0	1.2
11b	Design Resistance (Natural Condition)	kg/cm²	2.0	2.5
12	Filtration Coefficient	m/day	0.6	0.4

The standard values of cohesion and internal friction angle were determined according to GOST 2205–75. Soil salinity ranges from 0.05 to 0.1% of dry mass, with sulfate–sodium–calcium and hydrocarbonate–sulfate types prevailing. Soil compressibility was evaluated through laboratory testing of nine undisturbed monolithic samples under water-saturated conditions.

Hydrogeological and reclamation zoning was based on geomorphological, lithological, hydrogeological, and soil property analyses. The area is situated on the right bank of the Kashkadarya River within an alluvial–proluvial plain. Groundwater occurs at depths of 5–10 m and has mineralization of 1–3.2 g/L. The geological profile is dominated by Quaternary sandy and sandy-loam deposits.

According to subsidence characteristics, the soils belong to Types I and II, with subsidence being the main physical-geological process. Overall, the hydrogeological and reclamation conditions are considered satisfactory for the proposed reconstruction project.

Design Quantities for the Reconstruction of the Qumdaryo Canal

Summary of Major Earthwork Volumes

The main earthwork quantities associated with the project are summarized in ***Table 1.2***.

№	Canal Name	Length (km)	**Earthworks, m³**			Concrete Works, m³	
			Embankment Fill	Excavation	Backfill	Cast-in-Place Concrete	Reinforced Concrete
1	Qumdaryo Canal	1.916	5760	3641	1960	1233.45	-

The concrete lining of the Qumdaryo flood diversion canal has deteriorated significantly, exhibiting collapse, cracking, and the formation of erosion gullies. As a result, mudflow and floodwaters cannot be conveyed safely, leading to a

deterioration in water supply conditions for approximately 800 hectares of irrigated land. Arid soil conditions, high evaporation rates, and natural drainage characteristics further contribute to serious hydraulic engineering challenges.

Proposed Measures

To ensure the safe conveyance of mudflow and flood flows and to improve the efficiency of the irrigation system, it is recommended to reconstruct a 0.5-km section of the canal by installing a new concrete lining and eliminating the existing erosion features. In addition, the construction of a rapid-flow drop structure at PK5+00 is proposed to regulate high-velocity water flows and maintain hydraulic stability.

Furthermore, it is necessary to optimize reclamation measures within the irrigation and drainage systems by maintaining permissible flow velocities and taking into account soil subsidence characteristics and filtration coefficients. The implementation of a hydrogeological monitoring system is also recommended to enable timely detection and prevention of adverse groundwater-level fluctuations within the project area.

Conclusion

The conducted analyses indicate that the current condition of the Qumdaryo flood diversion canal is unsatisfactory from a hydraulic engineering perspective. Reconstruction of the canal and construction of the proposed rapid-flow drop structure will reduce mudflow and flood hazards, improve water supply to irrigated lands, and increase agricultural crop productivity.

The proposed engineering measures, developed with consideration of the hydrogeological and soil conditions of the area, possess both scientific and practical significance. In addition, continuous monitoring and technical supervision will contribute to ensuring the long-term hydraulic safety and sustainable operation of the hydraulic infrastructure within the region.

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