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ГИДРАВЛИЧЕСКАЯ ОЦЕНКА ВОДОВЫПУСКНОГО СООРУЖЕНИЯ И НИЖЕРАСПОЛОЖЕННОГО КАНАЛА ТУДАКУЛЬСКОГО ВОДОХРАНИЛИЩА

Аннотация: В работе рассмотрены сообщённые параметры водовыпускного сооружения и отводящего канала Тудакульского водохранилища. Для трапецеидального русла при ширине дна 14 м, глубине 4 м и коэффициенте заложения откосов 1,5 расчётная площадь полного сечения составляет 80 м², ширина по верху — 26 м, смоченный периметр — 28,42 м, гидравлический радиус — 2,81 м. При допущении о полном сечении условные средние скорости равны 0,313, 0,350 и 0,625 м/с для расходов 25, 28 и 50 м³/с соответственно. Согласно предоставленным эксплуатационным материалам, существующая пропускная способность 25–28 м³/с составляет 50–56% от указанного проектного расхода 50 м³/с. Поскольку фактическая глубина, продольный уклон, шероховатость и измеренные скорости не представлены, результаты являются геометрическими и условными и не подтверждают фактическую пропускную способность канала.

Ключевые слова: водохранилище; водовыпускное сооружение; отводящий канал; расход воды; скорость потока; пропускная способность.

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HYDRAULIC ASSESSMENT OF THE TUDAKUL RESERVOIR OUTLET AND DOWNSTREAM CONVEYANCE CHANNEL

Abstract: This study evaluates the reported discharge conditions and channel geometry of the Tudakul Reservoir outlet route using available technical records and standard cross-section relationships. For a trapezoidal channel with a

bottom width of 14 m, depth of 4 m, and side-slope coefficient of 1.5, the full geometric area is 80 m², the top width is 26 m, the wetted perimeter is 28.42 m, and the hydraulic radius is 2.81 m. Under the full-area assumption, conditional mean velocities are 0.313, 0.350, and 0.625 m/s for discharges of 25, 28, and 50 m³/s, respectively. The reported existing route capacity of 25–28 m³/s equals 50–56% of the 50 m³/s design discharge stated in the supplied operating material. Because actual depth, slope, roughness, and field velocity measurements were unavailable, these calculations do not verify the channel's actual conveyance capacity.
Keywords: reservoir; outlet structure; downstream channel; discharge; flow velocity; conveyance capacity.

INTRODUCTION

Reservoir operation includes storing and releasing water according to an established regime, monitoring the technical condition of hydraulic structures, and regularly analyzing measurement results [1, 2]. The conveyance capacity of an outlet structure and its downstream channel is directly related to the reservoir drawdown regime. Hydraulic assessments use channel geometry, discharge, flow velocity, hydraulic radius, roughness coefficient, and longitudinal slope [3].

The supplied technical and operational materials for the Tudakul Reservoir report a design discharge of 50 m³/s for the outlet structure and an existing conveyance capacity of 25–28 m³/s for the downstream release route [8]. The source describes the downstream channel as an earth channel with a bottom width of 14 m, a full geometric depth of 4 m, and a side-slope coefficient of 1.5. These reported values permit a conditional geometric comparison; they do not constitute new field measurements.

The study evaluates the reported discharge conditions and geometric conveyance indicators of the Tudakul Reservoir outlet route and identifies the hydraulic and operational parameters needed for monitoring. The analysis uses the supplied technical records, published textbooks, applicable regulatory

documents, and international monitoring guidance. It does not determine actual channel capacity from field measurements.

MATERIALS AND METHODS

The analysis used working technical and operational materials for the Tudakul Reservoir [8]; three textbooks on reservoir hydrology, operation, and hydraulics [1–3]; two regulatory documents concerning embankment dams and loads and actions on hydraulic structures [6, 7]; and two international technical manuals on dam instrumentation and monitoring [4, 5]. The numerical input data are summarized in Table 1.

Table 1. Input data used in the calculations

Parameter	Symbol	Value	Source
Design discharge of the outlet structure	Qdesign	50 m³/s	[8]
Existing discharge capacity of the release route	Qexisting	25–28 m³/s	[8]
Bottom width of the downstream channel	b	14 m	[8]
Channel depth	h	4 m	[8]
Side-slope coefficient	m	1.5	[8]
One barrel of the outlet conduit	B × H	3.10 × 4.30 m	[8]

The downstream channel was treated as a trapezoidal section. Its full geometric properties were calculated using the standard relationships presented in the reservoir hydraulics source [3]:

$$A = (b + mh)h; \quad B = b + 2mh; \quad \chi = b + 2h\sqrt{(1 + m^2)}; \quad R = A/\chi,$$

where A is the flow cross-sectional area, m²; B is the top width, m; χ is the wetted perimeter, m; and R is the hydraulic radius, m. Mean velocity was calculated as the ratio of discharge to cross-sectional area: v = Q/A.

The value h = 4 m was used as the full geometric depth. Therefore, the resulting velocities are not field measurements; they are conditional mean values calculated for the same full cross-sectional area of 80 m². Because the supplied materials do not provide reliable values for the existing water depth, longitudinal

channel slope, or Manning roughness coefficient, discharge was not recalculated with the Manning equation.

RESULTS

For b = 14 m, h = 4 m, and m = 1.5, the full cross-sectional area of the downstream channel is A = 80.0 m², the top width is B = 26.0 m, the wetted perimeter is χ = 28.42 m, and the hydraulic radius is R = 2.81 m. Conditional mean velocities for the design and existing discharge conditions are presented in Table 2.

Table 2. Calculated values for the discharge conditions

Condition	Discharge Q, m³/s	Area A, m²	Conditional velocity v, m/s	Share of design discharge, %
Existing lower limit	25	80.0	0.313	50
Existing upper limit	28	80.0	0.350	56
Design condition	50	80.0	0.625	100

The three discharge conditions in Table 2 are shown in Figure 1. The conditional mean velocities calculated from these discharges and the full 80.0 m² cross-sectional area are shown in Figure 2.

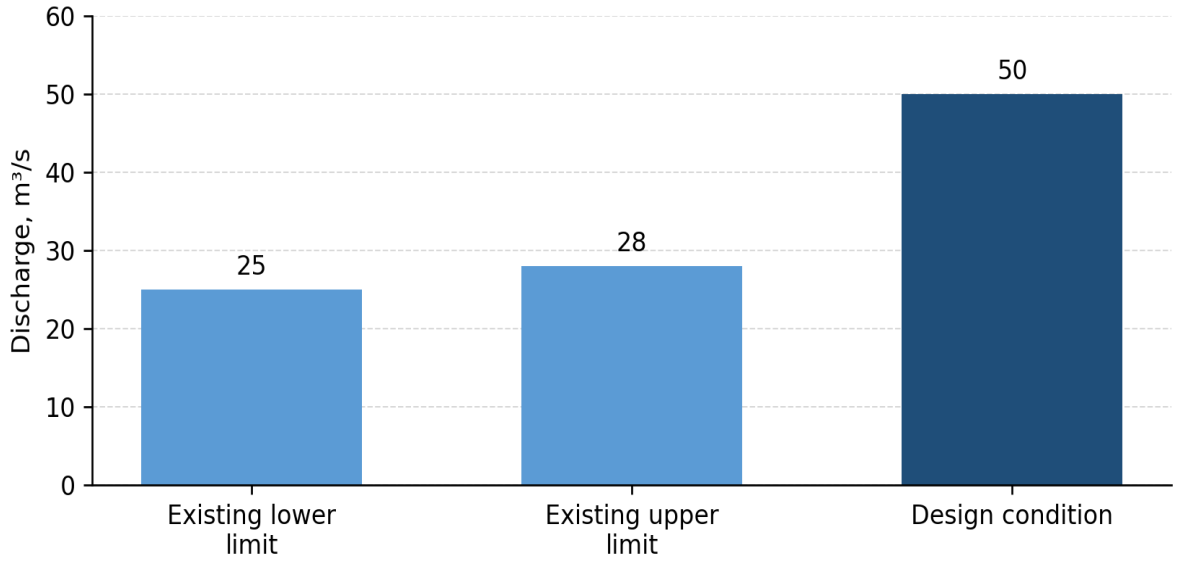


Figure 1. Comparison of discharge conditions

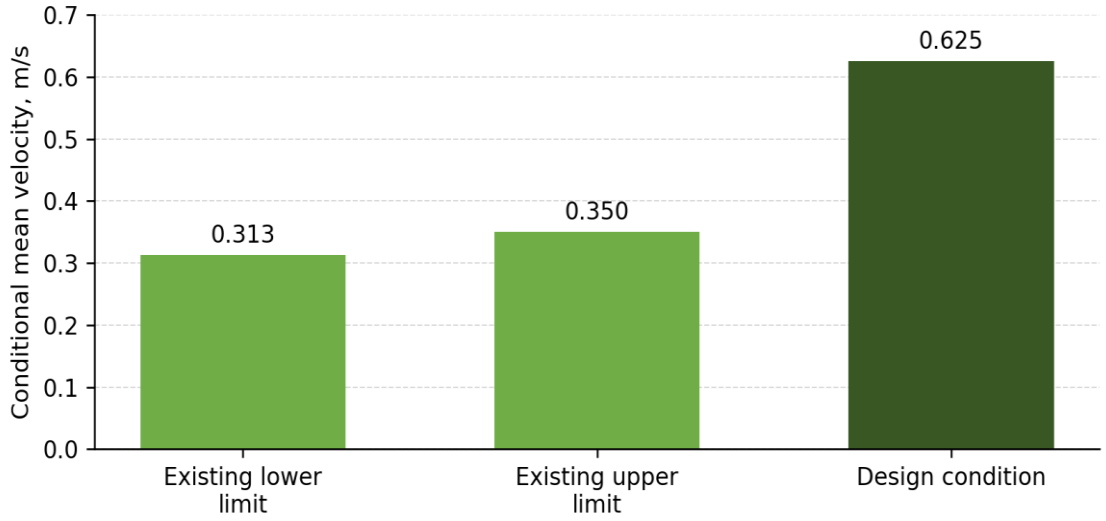


Figure 2. Comparison of conditional mean velocities for the full geometric section

The existing conveyance capacity of 25–28 m³/s corresponds to 50–56% of the design discharge of 50 m³/s. Accordingly, the reduction relative to the design value is 44–50%. These percentages were calculated from the ratios 25/50 and 28/50 and are not separate field measurements.

The supplied technical material gives a full reservoir volume of 1,200 million m³ and a regulated volume of 600 million m³. It also states that, with evaporation considered, reservoir drawdown requires 100–120 days at a conveyance capacity of 50 m³/s, whereas the existing capacity of the release route extends this period to 150–170 days [8]. These data distinguish the capacity of the outlet structure itself from that of the downstream conveyance route.

The supplied technical material attributes the reported reduction in downstream-channel conveyance from 50 m³/s to approximately 25–28 m³/s to sedimentation and vegetation growth [8]. It also records bridges, pipes, and other structures along the release route [8]. The present analysis adopts the reported 25–28 m³/s range; it does not independently establish the route capacity or the causes of the reported reduction.

DISCUSSION

The reservoir operation sources describe visual and instrumental inspection, recording results in observation logs, and comparing detected changes with previous measurements as components of operational monitoring [1, 2]. The reservoir hydraulics source treats discharge, cross-sectional area, velocity, hydraulic radius, channel slope, and roughness coefficient as interrelated parameters for evaluating flow conditions [3].

SHNQ 2.06.05-21 governs embankment dams made of soil materials, while SHNQ 2.06.04-21 addresses loads and actions on hydraulic structures [6, 7]. These design standards provide regulatory context for the reservoir complex; they are not used here as direct evidence of measured channel capacity or as a substitute for an operational monitoring program. The supplied Tudakul materials describe the dam, outlet structure, downstream channel, and monitoring systems as parts of one hydraulic complex [8].

The Bureau of Reclamation guidance links instrumentation and monitoring to evaluation of structure performance and response to unusual data [4]. The U.S. Army Corps of Engineers guidance states that a monitoring program should include instrument maintenance, data collection and management, plotting, evaluation, and reporting procedures [5]. In these sources, monitoring data are treated as inputs to evaluation and decision-making rather than as isolated measurements.

When the supplied sources are considered together, the following variables describe the condition of the outlet conveyance route: water level, discharge, existing flow depth, cross-sectional geometry, mean velocity, sedimented and vegetated reaches, and the condition of bridges and pipes. This list is not presented as a new technical standard; it systematizes the monitoring and hydraulic parameters identified in sources [2–5, 8].

CONCLUSION

1. The supplied technical material gives a design discharge of 50 m^3/s for the Tudakul Reservoir outlet structure and an existing conveyance capacity of 25–28 m^3/s for the downstream release route.
2. For b = 14 m, h = 4 m, and m = 1.5, the full channel section has an area of 80.0 m^2, a top width of 26.0 m, a wetted perimeter of 28.42 m, and a hydraulic radius of 2.81 m.
3. For the same full cross-sectional area of 80.0 m^2, the conditional mean velocities are 0.313 m/s at 25 m^3/s, 0.350 m/s at 28 m^3/s, and 0.625 m/s at 50 m^3/s. These values are not field velocity measurements.
4. The existing conveyance capacity of 25–28 m^3/s equals 50–56% of the design value. The technical source relates the reduction to sedimentation, vegetation growth, and structural elements along the route.
5. According to the supplied sources, evaluation of the outlet conveyance system requires regular recording, storage, and comparison of discharge, water level, flow depth, velocity, channel geometry, and flow-obstructing conditions.

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