水庫排砂暨下游河道沖淤運轉策略研擬分析

Strategy Analysis of Reservoir Sediment Desilting and Downstream River Channel Flushing Operation

國立中興大學土木工程學系助理教授	國立臺灣大學水工試驗所研究員暨生物環境系統工程學系兼任教授	國立臺灣大學水工試驗所專任研究助理	國立成功大學研究發展基金會副研究員	多采工程顧問公司董事長
李豐佐	賴進松	劉政其	吳嘉文	李文生
Fong-Zuo Lee	Jihn-Sung Lai	Cheng-Chi Liu	Chia-Wen Wu	Wen-Sen Lee

摘要

近年來，水庫下游河道放淤及庫區抽泥已成為水庫防淤的重要措施，因此掌握防洪水量並進行水庫下游河道的沖淤操作顯得尤為重要。本研究以曾文水庫為研究區域，收集並彙整了曾文水庫上游大埔水文站獲得的流量與輸砂量關係式，利用該關係式可根據預報的入庫流量推求入庫砂量。本研究還利用二維數值模式進行入庫泥砂運移模擬分析，通過混合入庫渾水與庫區水體，推估泥砂濃度。二維模擬結果顯示，入庫渾水到達壩前的濃度可精確推估，並建立壩前泥砂濃度推估值與二維數值模式模擬值的相關性。由歷史事件的推估結果可知，在固定時間內可能對應多個泥砂濃度值，這主要是因為運算過程中使用逐時資料，可能發生入流渾水逐漸加快並追上先前時刻運移的渾水現象。但整體而言，演算結果顯示渾水到達壩前的時間以及尖峰泥砂濃度到達壩前的時間均可準確掌握。根據這些推估模式，並結合水價值的估算和水力抽泥替代成本的考量，本研究研擬了水庫排砂及下游河道沖淤的運轉策略。如果以現況曾文水庫抽泥成本約為$100/立方公尺為基礎，則在壩前泥砂濃度為 6 萬 ppm 的條件下，對應的抽泥成本約為$4.00；而對應的水量移用費約為$3.99，二者相當。因此，可以壩前泥砂濃度 6.0 萬 ppm 作為門檻值，若水庫無須防洪運轉，但壩前濃度超過此門檻，則開啟防淤隧道進行水力排砂仍具效益。根據此原則，可以擬定水庫排砂暨下游河道沖淤的運轉策略分析流程。

關鍵詞：河道放淤、沖淤、二維數值模式、運轉策略

Abstract

In recent years, sediment replenishment in downstream river channels and dredging in reservoir areas have become important measures for sediment deposition prevention in reservoirs. Therefore, managing floodwater volume and conducting desilting operations in downstream river channels are particularly important. This study focuses on the Zengwen Reservoir, collecting and compiling the flow and sediment transport relationships obtained from the Dapu hydrological station upstream of the reservoir. Using these relationships, the incoming sediment yield can be estimated based on forecasted inflow discharge. The study also utilizes a two-dimensional numerical model to simulate the movement of incoming sediment, estimating sediment concentration by mixing incoming turbid water with reservoir water. The results of the two-dimensional simulations indicate that the concentration of turbid water reaching the dam front can be accurately estimated, establishing the correlation between the estimated sediment concentration at the dam front and the values simulated by the two-dimensional model. Historical event estimates show that multiple sediment concentration values may correspond to fixed times, mainly because hourly data is used in the calculations, which may result in faster incoming turbid water catching up with previously transported turbid water. However, overall, the calculation results show that the time of turbid water arrival at the dam front and the peak sediment concentration time can be accurately grasped. Based on these estimation models, combined with the evaluation of water value and the consideration of hydraulic dredging replacement costs, this study has formulated an operation strategy for sediment deposition prevention in reservoirs and flushing in downstream river channels. If the current dredging cost of Zengwen Reservoir is approximately $100 per cubic meter, then at a sediment concentration of 60,000 ppm at the dam front, the corresponding dredging cost is about $4.00; the corresponding water transfer cost is about $3.99, which are roughly equivalent. Therefore, using a dam front sediment concentration of 60,000 ppm as a threshold, if there is no need for flood control operations but the concentration exceeds this threshold, opening the desilting tunnel for hydraulic sediment flushing is still beneficial. According to this principle, an operation strategy analysis process for reservoir desiltation operation and downstream river channel flushing can be formulated.

Keywords: sediment replenishment, sediment flushing, two-dimensional numerical model, operation strategy