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Research article

Three-Dimensional Analysis of Seepage in Fractured Rock Masses and Evaluation of the Accuracy of Empirical Methods for Predicting Permeability in Cutoff Walls: A Case Study of Chamshir Dam

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Abstract

The assessment of the permeability of fractured rock formations plays a crucial role in optimizing the design of impermeable layers in dam construction projects. Uncontrolled seepage and deficiencies in the preparation of dam foundations and abutments are among the primary causes of dam failures. This study focuses on the investigation of the permeability of fractured rock masses and the design of a cutoff wall using numerical modeling techniques. The fracture network was modeled using the discrete element method (DEM) in the 3DEC software, considering the joint patterns specific to the region. Geological conditions were incorporated into the three-dimensional model to enhance its realism and accuracy. The numerical model was validated by comparing its results with data obtained from Lugeon tests, ensuring the reliability of the simulations. The cutoff wall was designed in accordance with the geological and hydrogeological conditions of the site. The performance of the cutoff wall was analyzed by modeling two scenarios: one with the cutoff wall and the other without it, using the 3DEC and Seep/w software. Results from the seepage analyses conducted using these software tools showed that the implementation of the cutoff wall reduced seepage by 70% according to 3DEC and 80% according to Seep/w. Additionally, the permeability values obtained through various empirical methods were compared, and their errors were evaluated using the Root Mean Square Error (RMSE) index. The obtained RMSE values for the methods are as follows: Dupuit (0.2× 10^-7), Altovsky (1.1× 10^-7), Moye (0.18 × 10^-7), Hoek-Bray (0.15 × 10^-7), and Verigin (0.1 × 10^-7), respectively. The findings revealed that the Hoek method and Verigin method provided the most accurate results, exhibiting the least amount of error when compared to other empirical methods.

1. INTRODUCTION

The assessment of seepage in dams is critically important for addressing water leakage from foundations and abutments, as well as its impact on the stability of dam structures and their economic feasibility. Uncontrolled seepage or inadequate preparation of dam foundations and abutments has been reported as the main cause of numerous dam-related leakage problems and failures, with 30% of all failures attributed to seepage issues [1]. Consequently, extensive studies have been conducted to determine the extent and areas of seepage in dam abutments and to control it based on the hydrogeological conditions of dam sites, equivalent media theory,