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Research article

Comparison of Infinite Fracture Model (IFM) and Discrete Fracture Network (DFN) for Estimating the Volume of In-Situ Blocks in Dimension Stone Mines with a Focus on UAV Photogrammetry

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Abstract

The dimension stone extraction industry serves as a vital economic sector in numerous countries, particularly in Iran, necessitating the implementation of innovative and efficient methods to optimize extraction processes and manage mineral resources. This paper focuses on the application of digital photogrammetry techniques and drone technology in the extraction and modeling of dimension stone quarries, specifically examining the Josheghan marble mine located in Isfahan Province. The study emphasizes the significance of identifying and analyzing fractures as key factors in enhancing the quality of extracted blocks, illustrating how modern methodologies can lead to optimized extraction processes and increased profitability for quarries. The research is based on two principal hypotheses: the Infinite Fracture Model (IFM) and the Discrete Fracture Network (DFN) model. The IFM posits that fractures extend indefinitely within the rock mass, a premise that may lead to inaccurate estimations of block volumes. In contrast, the DFN model provides more precise estimations of block volumes and quality by accounting for the complexities of geological structures and the presence of hidden fractures. To achieve accurate information regarding fractures and the structural characteristics of the mine, several procedures were undertaken in this research. Following the initial survey, seven scanlines, each 22 meters in length, were established at various locations within the mine to gather detailed data on fracture intensity and related features. The results indicate that effective management of dimension stone resources is contingent upon a thorough understanding of geological conditions and precise modeling of discontinuities within the rock mass. The use of advanced techniques such as digital photogrammetry and drone technology can significantly enhance extraction efficiency, ultimately contributing to the sustainable development of the dimension stone industry. The parameters P10 and P32 in this study were utilized as the primary criteria for analyzing discontinuities. Using specialized software, 70 Discrete Fracture Network (DFN) models were generated and calculated separately based on the values of P32. These models were employed to simulate the behavior of rock blocks and estimate their volumes in the selected qua-contrast face. Ultimately, based on the data obtained from the conducted surveys, ten distinct DFN models were created for the entire area of the mine. These models were designed based on information related to hidden fractures and the structural complexities of the rock, facilitating more accurate estimations of the volumes of extracted blocks. The results indicate that the DFN model, by taking into account the real complexities present in the geological structure, provides more precise estimates of expected block volumes. This research clearly demonstrates that the application of modern photogrammetry methods and DFN modeling can enhance the extraction process of dimension stones. The insights gained from the analysis of discontinuities and modeling not only contribute to a better understanding of the geological structure of the mine but also lead to more effective managerial and economic decision-making in the field of mineral resource extraction. These findings could be particularly beneficial for dimension stone quarries in Iran, which face various challenges and could aid in sustainable development and optimization of mineral resources.

1. INTRODUCTION

In recent years, the integration of advanced technologies within the mining sector, particularly in the extraction of dimension stones, has ascended to a paramount priority. Among these technologies, the deployment of drones and digital