Application of Ground-Penetrating Radar (GPR) method to evaluate and control the quality of dimension stone blocks

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Extended Abstract

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Introduction

Dimension stones market is considered as an important and profitable sector of mineral deposit business due to their share in national economic performance. There exist a number of technical reports highlighting a lack of rock quality control in the sequence of quarrying and dimension stones production procedures, which has lowered the production efficiency and consequently the profitability of this strategic mineral industry in Iran. The quality of dimension stones depends on several factors which fractures, joints, voids and fine beddings are the most important factors that down-grade the quality. Therefore, foremost the quality and desirability of the building stone must be precisely determined by sampling, compressive strength testing and preparing microscopic sections. All of the mentioned evaluation methods are destructive. Moreover, sampling and performing multiple tests on all parts of a quarry or on all quarried stone blocks, is not possible. Detection of fractures hidden into the dimension stone blocks is achievable using fast, low-cost, accurate and non-destructive ground-penetrating radar (GPR) method. GPR is a high-resolution geophysical method which uses electromagnetic waves with high-frequency in order to map structures and detect buried objects in subsurface without coring or any destruction of the medium.

Materials and methods

In current research, GPR method has been applied to evaluate the quality of quarried travertine blocks at Haji-Abad quarry complex in Mahallat district, Markazi province, before starting any processing operation. To achieve this goal, the 2-D GPR responses of synthetic models resembling cubic dimension stone blocks containing fine layering and discontinuities, were primarily simulated using a modified 2-D finite-difference forward modeling program in the frequency-domain coded in MATLAB. Among the variety of available numerical methods, the finite-difference time-domain (FDTD) method has paid more attention due to having the simple understanding of the concepts, flexibility, simulation and modeling of complex environments and the acceptability of its responses in the applied cases. In this research, the simulation has been implemented for both calcareous and dolomitic rocks (including travertine and marbles) and granites. In the study area, the GPR data acquisition was carried out using a GPR system equipped with shielded 250 MHz central frequency antenna, 0.5 m antenna distance and 2 cm sampling intervals by monostatic common-offset reflection profiling method. In order to process, analyze and interpretation of data, Ground Vision and Radexplorer software were employed. The most important pre-processing and processing operations applied to the data to provide the final sections, comprising time-zero correction, dewowing (removing very low frequency components from the data), DC shift removal, Butterworth filtering, running average, background removal and types of amplitude gain.

Results and Conclusion

The results of the forward modeling show that the GPR response of fine beddings interfaces and major discontinuities hidden in the volume of dimension stone blocks are clearly detectable. Interpretation of the actual radargrams taken from a real GPR case study (Haji-Abad quarry complex) after employing various B-scan pre-processing and filtering procedures, indicates that GPR method is highly capable to detect fine beddings and discontinuities in order to evaluate the quality of dimension stone before

starting any quarrying process. Validation of the obtained results of the present research was carried out on one of the blocks with a predicted large oblique joint while the existence of the large joint was proven under the cutting saw in the stone processing plant. However, it should be noted that due to the existence of inherent heterogeneity encompassing fine beddings, in addition to noises from different sources and their associated multiple reflections in real radargrams, the response of shallow major discontinuities may mask the response of minor ones located underneath or deeper, so as a result may not be detectable with routing GPR radargrams.

Keywords: Dimension stone Blocks (cubes); dimension stones production; Ground Penetrating Radar (GPR); Forward modeling; Quality control; Haji-Abad mining complex in Mahallat

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