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Engineering geological modeling of building stones (case study: Mahallat, Hajiabad travertine)

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Abstract

In the current research, geological-geomechanical modeling of the Mahallat, Hajiabad Travertine was conducted using 90 boreholes with a total length of 663.35 meters, at a large scale. To achieve the goal, first, 2D geological-geomechanical strip-logs, 3D lithological strip-logs, 3D lithological model of all boreholes, 3D fence diagram of lithology variations for the boundary boreholes and isopach map of the mining deposit were drawn. Afterward, statistical studies of the Core Recovery (RC) and Rock Quality Designation (RQD) data of the boreholes were performed, as well as 3D model of the RC data, 3D statistical map and 3D model of the RQD data were generated.
The results of the research show that the average thickness of the deposit (containing travertine and marly travertine) equals 4.05 meters, and the remaining reserve within the boreholes boundary is estimated 5,868,439 tons, indicating a significant and worthwhile reserve. The average RC of the boreholes is 77.4%, reflecting a relatively high quality of drilling operation and the deposit content. Also, the average RQD in the boreholes is 69.3%, classifying the quality of the Hajiabad Travertine based on the engineering rock classification using the RQD criterion as "fair". Based on the 3D statistical map of RQD data, the highest RQD values belong to the boreholes in the southern half of the area. The 3D model of the RQD also indicates that, in general, the quality of the Hajiabad Travertine stones are better in zones 6E, 6W, and 14 compared to the other zones.

Keywords: *Building stone, Mahallat Hajiabad, Modeling, Lithology, Core Recovery, Rock Quality Designation*

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Extended Abstract:

1. Introduction

Hajiabad travertine quarry is located in the southwest of Mahallat city and 5 km of Mahallat-Khomein road. This mining district is located in the structural zone of Central Iran, Golpaygan 1:250,000 geological map and Mahallat 1:100,000 geological sheet. The Hajiabad Travertine region has a relatively mild hill-axis morphology and is located between the foothills and plain. These hills mostly with low-height and flat surface, comprise sandstone, marl, and Eocene shales and the old Quaternary travertine units have been deposited on these heights, with angular unconformity in the region. In this mining area, travertine deposits have taken place between two conglomerate units during two generations. Due to the large area, the region has been divided into 18 zones, while with the passage of time, stone quarrying from the various zones and reduction of the zones area, the division of the region has changed. Currently, this region includes 11 zones named 6E, 6W, 8E, 8W, S3, L10, 1, 12, 14, 15 and 17. The compressive strength of the Hajiabad travertine is on average 500 kgf/cm^2 (50 MPa), its density is between 2.4 and 2.7 gr/cm^3 (on average 2.5 gr/cm^3) and water absorption percentage is between 0.2 and 0.7 percent (0.35 percent on average). In order to explore new reserves, access to intact stone, determining the quality, thickness and as a result amount of reserves, 90 vertical exploratory boreholes called BH1 to BH90 with a total length of 663.35 m have been drilled in the region.

2. Materials and methods

In the current research, geological-geomechanical modeling of the Mahallat, Hajiabad Travertine was conducted using 90 boreholes at a large scale through RockWorks 2022. In this regard, lithology and geomechanical characteristics containing core recovery (RC) and Rock Quality Designation (RQD) were investigated (Akingboye, 2023; Yong et al., 2022; Lukić, and Zlatanović, 2017; Pells et al., 2016; Hencher, 2015; Jaeger et al., 2007; Carter, 1992; Goodman, 1991; Bieniawski, 1989; Deere, 1989, 1963). To achieve the goal, 2D geological-geomechanical strip-logs, 3D lithological strip-logs, 3D lithological model of all boreholes, 3D fence diagram of lithology variations for the boundary boreholes and isopach map of the mining deposit were drawn. In order to investigate the structural and tectonic situation in the Hajiabad region, first, joint study was carried out in the variety of zones. Afterward, statistical studies of the Core Recovery (RC) and Rock Quality Designation (RQD) data of the boreholes were performed, as well as 3D model of the RC data, 3D statistical map and 3D model of the RQD data were generated.

3. Tests results

The results of the structural investigation of the region through fractures surveying in the various zones and drawing rose diagrams in the first step, revealed that in general the frequency of fractures in the variety of zones and as a result the entire Hajiabad travertine area is relatively high, but based on field evidences, tectonic activities in the region have not lead to crushing the rocks, without affecting on the health of the rock. A detailed study of all cores from drilled boreholes showed that in general, the lithological diversity in the region is relatively high with seven lithology units containing travertine, marly travertine, clays, shale, marl, conglomerate and sandstone. The results of the research show that the average thickness of the deposit (containing travertine and marly travertine) equals 4.05 meters, and the remaining reserve within the boundary boreholes is

estimated 5,868,439 tons, indicating a significant and worthwhile reserve. The average RC of the boreholes is 77.4%, reflecting a relatively high quality of drilling operation and the deposit content. Also, the average RQD in the boreholes is 69.3%, classifying the quality of the Hajiabad Travertine as "fair" based on the engineering rock classification using the RQD criterion.

4. Conclusion

Based on the 3D statistical map of RQD data, the highest RQD values belong to the boreholes in the southern half of the area. The 3D model of the RQD also indicates that, in general, the quality of the Hajiabad travertine stones are better in zones 6E, 6W, and 14 compared to the other zones. It is also necessary to mention that although the RQD index alone is not sufficient in all fields of quality assessment and rock mass engineering classifications, but in the case of building stones, can be the criterion of stone quality. Especially for large-scale decision-making, such as the present case study or similar cases, which the stone strength is already known and acceptable through laboratory tests on core samples from point locations, and the stone quality should be evaluated on a large scale, RQD has a high efficiency. The results of this research will be useful for all earth science users, especially engineering geologists and mining engineers involved in the field of planning and evaluation of building stone quarry.

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