Ain Shams University
Faculty of Engineering
Department of Structural Engineering

Slope Stability of Jointed Rock Masses

BY

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THESIS

Submitted in partial fulfillment of the requirements for
Degree of Doctor of Philosophy in Civil Engineering
Structural Engineering Department
(Geotechnical Engineering)

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of doctor of philosophy in civil engineering.

The work included in this thesis was carried out by the author in the Department of structural Engineering, Ain Shams University from 2008 to 2012.

No part of this thesis has been submitted for a degree or for qualification at any other university or situation.

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Abstract of the Ph.D. Thesis submitted by:

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Abstract

The mechanical behavior of jointed rock masses is determined by the properties of the rock matrix, geometry and properties of discontinuities. Joints and other geologic structures often increase significantly the deformability, and reduce the strength of the systems. The main problem with natural slopes, that its failure is unpredictable. The study of discontinuities in rock slopes is a very important factor for its stability and also for the safety of near habitants. Mokattam plateau slopes in Egypt are an example for hazard rock slopes surrounded by high population densities. Presence of intercalated shale layer in the Mokattam slopes causes a lot of instability problems due to shale softening and degradation when subjected to humidity or leakage resulting in many fatal accidents in the last years due to rock fall on humans and buildings. Most of the last stability researches use continuum or empirical approaches (ex; finite element programs). This approach is acceptable in the case of heavily jointed rock masses. But in reality, the rock mass is controlled by movement of joint-bounded blocks and/or intact rocks deformation, simulation of large displacements and large rotations is difficult with this method. Numerical modeling of jointed rock slopes using discontinuum distinct element techniques has proved to be the most reliable technique in these analyses.

The main objective of the present thesis is to investigate the behavior and stability of jointed rock slopes using discontinuum distinct element code (UDEC). This was conducted by designing and programming an analyzed model to analyze the stability of this complicated rock slopes. The designed model was applied on the Mokattam upper plateau slope and the model results were compared with the available field displacement readings to ensure the accuracy of the designed model in addition with taking into account the softening of shale layer on five steps. The developed model results agree well with the field results. Accordingly, an extensive parametric study was carried out to determine the effect of five important joint properties on the stability of rock slopes (which are joint shear stiffness, joint normal stiffness, joint friction, joint cohesion and joint tension) also, the effect of shale layer properties and its inclination. Design and guideline values were represented for these parameters which will benefit researchers in their future studies and analyses. Also, an economic mean of protection was suggested to protect the population surrounding the upper Mokattam plateau slopes by determining the safe catchment length below these slopes using another developed analysis model which simulate a practical rock fall for one of these slopes. Accordingly, the actual evacuation areas could be determined and implemented by state institutions.

Finally, this research project has helped to identify the jointed rock slopes behaviour and its associated problems in the Mokattam area and to increase the sensitivity of the proposed measures, which can help in mitigating the slope failure reasons and to achieve security of the population.

Keywords: Rock masses; Joints; Shale; Displacement; Shear stiffness; UDEC; Stability

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