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Slope Stability of Jointed Rock Masses

BY

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THESIS

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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

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

TABLE OF CONTENTS

Title	Page
TABLE OF CONTENTS	I
LIST OF FIGURES	VII
LIST OF TABLES	XIX
NOTATIONS AND SYMBOLS	XXIII
CHAPTER 1 INTRODUCTION	1
1.1 General	1
1.2 Objectives of This Research	3
1.3 Organization of the Present Work	4
CHAPTER 2 LITERATURE REVIEW	6
2.1 General	6
2.2 Introduction To Rock Slopes	6
2.3 Structural geology and strength of Jointed Slopes	7
2.3.1 Importance of geological investigations	7
2.3.2 Discontinuities Types and Joints Orientation	7
2.3.3 Parameters Defining Rock Mass Characteristics	9
2.3.4 Rock mass classification	14
2.3.5 Shear Strength of Infilled Discontinuities	15
2.3.6 Shear Strength of Filled Discontinuities	21
2.3.7 Ground Water Effect on Jointed Rock Masses	26
2.4 Types of Rock Slopes Failure	26
2.5 Methods of Analysis of Slope Stability	29

2.5.1	Conventional Methods of Rock Slope Analysis	30
2.5.1.1	Empirical and Analogue Approaches	30
2.5.1.2	Stereographic and Kinematic Methods	31
2.5.1.3	Slope Stability Charts	31
2.5.1.4	Limit analysis and Limit Equilibrium Methods	31
2.5.1.5	Probabilistic Methods	33
2.5.1.6	Physical Modeling	35
2.5.1.7	Block Models Theory	36
2.5.1.8	Rockfall Simulation	37
2.5.2	Numerical Methods	40
2.5.2.1	Continuum Modelling	42
a)	Finite Element Method	42
b)	Finite Difference Method	43
c)	Boundary Element Method	46
2.5.2.2	Discontinuum Modelling	48
a)	Distinct Element Method	48
b)	Discrete Element Method	49
2.5.2.3	Hybrid/Coupled Modelling	51
2.5.3	Comparison between Numerical and Conventional Methods	52
2.6	Protection and treatment to Rock Slopes	54
CHAPTER 3	RECENT CASE STUDIES ON MOKATTAM PLATEAU SLOPES	58
3.1	General	58
3.2	Introduction On Mokattam Plateau	58

3.3	Topography and Geology of Mokattam Plateau	59
3.4	Geotechnical Properties	62
3.5	Previous studies on Mokattam Slopes and Failures	66
3.6	Recent 2008 Failure in Mokattam plateau:	74
3.7	Factors Affecting Mokattam slopes stability:	76
CHAPTER 4 UDEC MODELLING AND SENSITIVITY STUDY		77
4.1	General	77
4.2	Universal Distinct Element Code (UDEC) program	77
4.2.1	Numerical Formulation	78
4.2.2	Block Constitutive models	78
4.2.3	Joint Material Models	82
4.2.4	Fields of Application	83
4.2.5	Validation of UDEC	83
4.3	Effect of Model Size on UDEC Results	84
4.3.1	Introduction	84
4.3.2	Model Shape	86
4.3.3	Input parameters	88
4.3.4	Numerical Results	89
4.3.4.1	Effect of Model Size on Maximum Displacement	90
a)	Effect of Slope Height (H) on Maximum Displacement Vectors	90
b)	Effect of Bedrock Height (Y) on Maximum Displacement Vectors	90
c)	Effect of Top Horizontal distance (Hz1) on Maximum Displacement Vectors	93
d)	Effect of Bottom Horizontal distance (Hz2) on Maximum Displacement Vectors	93

4.3.4.2	Sufficient Damping Lengths for Horizontal Displacement Contours	96
a)	Effect of Bottom Horizontal distance (Hz2) on Sufficient Damping Lengths	96
b)	Effect of Top Horizontal distance (Hz1) on Sufficient Damping Lengths	96
4.3.5	Conclusions	99
CHAPTER 5 MODELLING OF MOKATTAM UPPER PLATEAU STABILITY “CASE STUDY”		100
5.1	General	100
5.2	Shale Softening Case Study (Mokattam 2002)	100
5.2.1	Data of Case Study	100
5.2.2	Model Description and Rock properties	102
5.2.3	Model Results and Comparison with Field measurements	107
5.2.4	Effect of Shale Layer Inclination	111
5.3	Shale Degradation and Squeezing Case Study	116
5.3.1	Data of Case Study	116
5.3.2	Model Description and Rock properties	117
5.3.3	Model Results	118
5.4	Conclusions of case study	121
CHAPTER 6 PARAMETRIC STUDY ON JOINT PROPERTIES		123
6.1	General	123
6.2	Model Description and Rock properties	123
6.3	Joint Shear stiffness (Jks)	125

6.3.1	Effect of Joint Shear stiffness (Jks) for Different Joint Types	126
6.3.2	Effect of Joint Shear stiffness (Jks) for Different Shale Inclination Angles	133
6.4	Joint normal stiffness (Jkn)	139
6.4.1	Effect of Joint Normal Stiffness (Jkn) for Different Joint Types	140
6.4.2	Effect of Joint Normal stiffness (Jkn) for Different Shale Inclination Angles	144
6.5	Joint Friction (Jf)	149
6.5.1	Effect of Joint Friction (Jf) for Different Joint Types	149
6.5.2	Effect of Joint Friction (Jf) for Different Shale Inclination Angles	154
6.6	Joint Cohesion (Jc) and Joint Tension (Jt)	158
6.6.1	Effect of Joint Cohesion (Jc) and Joint Tension (Jt) for Different Joint Types	158
6.6.2	Effect of Joint Cohesion (Jc) and Tension (Jt) for Different Shale Inclination Angles	163
6.7	Comparison Between Different Parameters	168
6.8	Conclusions of parametric study	171
CHAPTER 7 SUMMARY, CONCLUSIONS AND RECOMMEDATIONS		174
7.1	General	174
7.2	Conclusions	175
7.3	Recommendations	178
7.4	Recommended Future Studies	179
REFERENCES		180
APPENDIX (A)		194
A.1	FISH Langauge:	194
A.2	The Designed FISH Model:	195

A.3	The RockFall FISH Model:	201
	APPENDIX (B)	207
B.1	Shale Properties:	207
B.2	Joints Properties:	211
	APPENDIX (C)	216

LIST OF FIGURES

Table of Figures	Page
Figure (2.1): Parameters describing the rock mass; letters (“A” etc.) refer to description of parameter in text (Wyllie, 1999);.....	10
Figure (2.2) Relationships between shear and normal stresses on sliding surface for five different geological conditions (Transportation Research Board, 1996).	17
Figure (2.3) Definition of shear strength of discontinuity surface; (a) shear test of discontinuity; (b) plot of shear displacement vs shear stress; (c) Mohr plot of peak strength; (d) Mohr plot of peak and residual strength (After Wyllie and Mah, 2004).	17
Figure (2.4): Patton’s experiment on the shear strength of saw-tooth specimens (Patton, 1966).	18
Figure (2.5): Roughness profiles and corresponding JRC values (After Barton and Choubey 1977).	22
Figure (2.6): Alternative method for estimating JRC from measurements of surface roughness amplitude from a straight edge (Barton 1982).....	23
Figure (2.7): Estimate of joint wall compressive strength from Schmidt hardness (Deere and Miller, 1966).	24
Figure (2.8) Types of failure mechanism found in rock slopes and cliffs (After Allison, 1998).	27