Modeling of Rock Slopes Against Flexural Toppling Failure in Static and Dynamic Conditions (Physical, Numerical and Analytical Methods)

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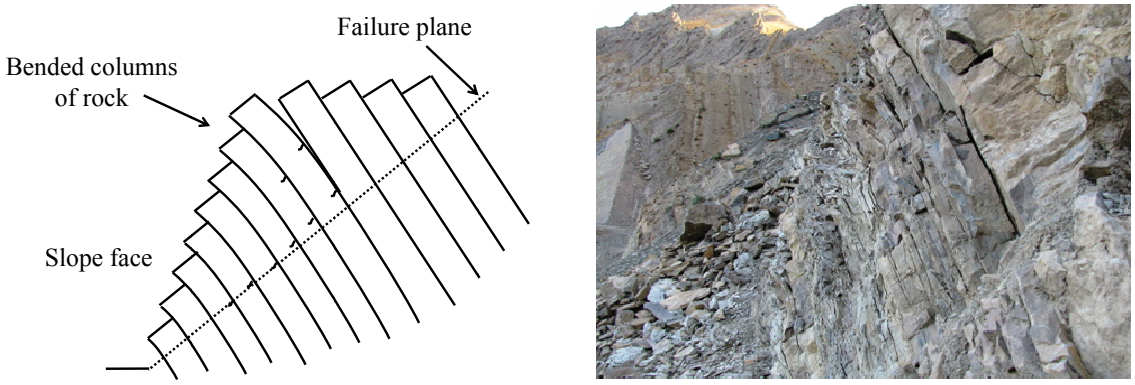
ABSTRACT

Flexural toppling is a mode of failure that may occur in a wide range of layered rock strata in both natural and excavated rock slopes. As illustrated in Figure 1, a typical flexural toppling can be occurring in a rock slope when columns of rock are separated by steeply dipping discontinuities and bended forward. Typical geological conditions for this type of failure are thin layers of sedimentary rocks such as slate and shale in which orthogonal jointing is not completely developed.



(a) Schematic view **(b) Photo of a failed rock slope**

Figure 1. Schematic view and photo of flexural toppling failure in rock slopes

In this study, the bending mode of flexural toppling is investigated analytically under both static and dynamic conditions and equations for factor of safety are developed. In order to

check the accuracy of the developed method, a series of physical models were conducted by means of laboratory scaled tilting and shaking tables. Furthermore, numerical models for all the physical models were reproduced in UDEC-DM software. Numerical models were run under the similar conditions corresponding to physical models and the results were compared with developed analytical equations as well as the results of the physical models.
The results of both physical and numerical models using a tilting table are summarized in Figure 2 and compared with developed analytical equation.

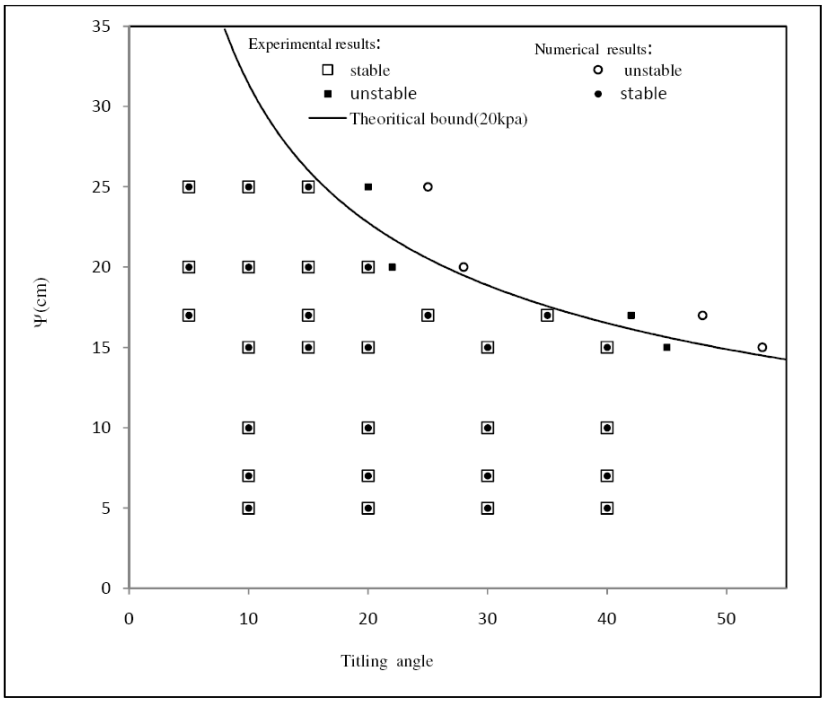


Figure 2. Results of physical and numerical models of rock slopes with potential of bending flexural toppling failure

The vertical axis in this figure is representing the average length of rock columns with potential of bending flexural toppling failure (Ψ) while the horizontal axis represents the tilting angle of the table on which the model is conducted. The developed analytical equation is plotted in this figure as a solid line which is separating the stable area (the area below the line) from the unstable area (the area above the line). The result points of physical and numerical models are shown in this figure where open and closed symbols refer to stable and unstable points respectively. It is obvious from this figure that there is good agreement between physical and numerical model results with developed analytical predictions.

Keywords: Rock Slope, Flexural Toppling Failure, Physical Modeling, Numerical Modeling