Study on Application of Discontinuous Deformation Analysis on the Stability Analysis of Slopes

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ABSTRACT
This study used Discontinuous Deformation Analysis (DDA) to investigate slope stability problem. The results suggested that, two shape factors must be considered for block stability on sliding surface, one is sphericity, the other is the ratio of contact length over block perimeter (C/P ratio). When estimating the factor of safety, if the number of slices is 9~11, the resulted estimation tends to be stable. The above analysis result is applied to the slope stability analysis in Huafan University, and the preliminary analysis result is compared against campus monitoring data, which serve as a reference for later correlation analysis and construction maintenance.

KEY WORDS: Limit Equilibrium Method, Slope Stability Analysis, Discontinuous Deformation Analysis.

INTRODUCTION
With dense population and limited land in Taiwan, proper reclamation and use of slope land is an inevitable trend. However, many adverse nature factors (such as storm, earthquake, river erosion, and sea wave erosion) and artificial factors (such as slope land overexploitation, improper site selection, over-reclamation and over capacity use, road exploring), lead to frequent slope land disasters, and result in danger to human life and loss of properties. Therefore, slope stability analysis is increasingly important. Traditional slope stability problem is often analyzed by the Limit Equilibrium Analysis, assuming the slope material to be homogeneous to identify the critical failure behavior. The slope in actual condition is affected by many external factors, resulting in numerous discontinuous surfaces. The commonly used analysis fails to meet field requirement sometimes, thus, Discontinuous Deformation Analysis (DDA) is proposed to simulate the slope stability by analysis, cutting slope into blocks.

Huafan University is located at the top of Dalun Mt., which is 550m above the sea level, in Shihting Shiang, Taipei County. The entire campus is on the slope land, thus slope stability is very important to the university. Research Center for Sustainable Development of Slope Areas, founded with the support from the Department of Environmental and Hazards-resistant Design, is responsible for monitoring the campus slope land safety through regular slope land safety monitoring. This study planned to simulate the campus slope stability problem by DDA, investigate the relationship of the number of slope slices and factor of safety or sliding trend. It also intended to find the optimal number of slices in slope analysis as the basis for determining number of blocks in later application analysis, and further apply the result in campus slope stability analysis. Lastly, it compared the preliminary analysis result against campus monitoring data for reference of later correlation analysis and construction maintenance.

INTRODUCTION OF DDA
DDA is a discontinuous deformation numerical analysis method proposed by Dr. Gen-hua Shih (1988). It uses the Minimal Energy Method to set up a simultaneous equation, and solve stress, displacement and deformation of every block element. Its solving process and steps are very similar to the Finite Element Method. The main difference is to treat each unit as a part of the continuous body or separable block. More specifically, the Finite Element Method maintains the analysis continuity by nodal points, so that elements can be deformed but cannot be separated; while DDA allows block elements to be deformable and separable, their relative positions are adjusted under expulsion and interaction. Thus, DDA is more suitable for actual state of soil or rock material, and can be used to simulate the mechanical behavior of continuous body, if increasing tension and spring stiffness among blocks. DDA has the following features:

(1) Complete block movement mechanism and numerical processing.
(2) Linear deformation.
(3) Satisfying equilibrium of internal and external forces.
(4) Adjusting energy loss.
(5) High execution efficiency.

Basic limits of DDA:
(1) Only two-dimensional problems are considered.
(2) Every block is treated as continuous body, with constant stress and strain.
(3) Material property of every block is assumed linear elastic.

Block interaction has two restrictions:
(1) Inter-penetration is not allowed.
(2) Tension is not allowed.