Chapter 11
Slope Stability of Soils

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ABSTRACT

Slope stability problems in soils underlie most of the landslides that cause losses of human and property in the world. The stability of natural or man-made slopes in soils is an important topic that requires great attention while site exploring, testing, modelling and analyzing. Engineering geology and geotechnical engineering interdisciplinary team work is essential to achieve a sufficient understanding of site geology and the behavior of soil. The developments of urban areas require new sites for settlement. Soil structure interaction in slopes requires more sophisticated numerical analysis methods to develop. This section particularly summarizes the factors cause a slope to fail. In addition, site exploration steps, in-situ and laboratory test methods were mentioned. Slope stability analysis methods such as LEM, FEM, DEM, BEM were discussed in details. The developments of empirical or statistical regional approaches were stated. Remediation techniques were discussed regarding the construction costs. Finally, the necessity of further studies in numerical modelling was emphasized.

1. INTRODUCTION

An inclined land surface with respect to horizontal is referred to as slope. The natural slopes are formed by natural factors i.e. weathering, crustal movements such as earthquakes, erosion, sedimentation, rainfall and seepage. There are also man-made slopes constructed by excavation or filling. Instability of these slopes may causes huge amount of economical and human losses. Therefore, in geotechnical slope stability is an important topic where the factors that provoke the slope of a soil to fail must be well understood. In the scope of a slope stability analysis, engineers can prepare preventative solutions for unfailed slopes or remediation projects for the failed slopes. Landslide susceptible regions can be categorized to request additional precautions in the local building codes or policy makers and landuse planners may restrict the unsafe sites for settlement according to landslide hazard maps prepared by a team of geologists, engineering geologists and geotechnical engineers.

This chapter is a literature review on slope stability of soils and summarizes the factors that provoke slope failure and common types of slope failure in soils. The effect of geological features and ground
water conditions on the stability of a slope is evaluated. The in-situ explorations and laboratory tests performed on soils are given. Slope stability analysis methods are discussed regarding the regional and site specific properties of soils. New trends and technologies on remediation techniques for landslides in natural soils are summarized. Construction, maintenance and remedial costs are compared relatively. Some early warning systems and future research area directions were mentioned.

2. BACKGROUND

Slope stability of soils is one of the major problems since the ancient times. If slope stability is the potential of a slope to landslide, natural or manmade factors that provoke this movement of a mass of soil, rock or debris down a slope have to be well understood to predict or to prevent the problem. While the best known natural causes are weathering and erosion, manmade applications such as cuts, fills, external loadings and changing the ground water level are some of the reasons stimulating a landslide.

The surficial area of a landslide may be smaller than 200 m² or even larger than 2,000,000 m². At the hillsides the landslide susceptibility of soils is higher than the soils in the lowlands. Similarly, for manmade structures as the angle or height of a slope increases, the stability of the slope decreases. So, the ground surface geometry of a slope is an important parameter on the stability. Slope angle, \( \beta \) is the angle of inclination of a ground surface. In road engineering applications, \( \beta \) is generally expressed in percent and it equals to meter rise or fall in height, \( H \) at 100 m horizontal distance, \( L \). The slope of a ground surface may be composed of a single plane or a series of planes with different inclinations. The plane of rupture below the ground surface is named as sliding surface. The mass of soil between the sliding surface and the ground surface is called as sliding mass that involves head, main body, toe, main scarp, minor scarp as shown in Figure 1. Length, width, depth and initial slope of the sliding mass is useful for describing the size of a landslide. Furthermore, the rate of the movement of landslide material may be as quick as debris or earth fall or as slow as soil creep. Varnes (1978) suggested a classification system for landslides based on type of the material involved and mode of the movement. In the system, the en-

![Figure 1. Parts of a landslide (modified from Varnes, 1978)](image-url)