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BEHAVIOR OF SLOPE STABILITY FOR EARTH DAMS

**A Thesis Submitted to Council of College of Engineering,
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the Degree of Master of Science in Civil Engineering**

by

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CHAPTER ONE

INTRODUCTION

1.1 General

Generally, dams are huge engineering constructions. They are held above or below a valley for many purposes. Dams are oldest hydraulic structures which are known to the man that are used in many fields such as: water storage, irrigation, power generation, navigation, flood control, nutrition the groundwater, etc. The dam can achieve more the purposes than these mentioned.

Usually, dams can be classified either according to their materials which are used in the construction and forms or objectives of constructing them. According to the materials, concrete dams in different types (are classified according to gravity, arch, buttress and multiple arch). In addition, embankment dams, which are common types that are classified into two types: dams that are constructed from one type of material like earth or rock that are called homogenous dams. While the other type of dams are constructed from multiple materials such as earth and rock materials they are called dams non-homogenous (zoned dams). (Novak, 2007). The choice of materials of building the dam is primarily on economic considerations. The main factors for the best types of dams for a specific location are topography and geology of the site and climate. A photo of Weand earth dam is illustrated in Figure 1.1.

In fact, this huge project need more and more study to cover all expected issues that affect the dam performance. The new technology and programs can be used to assess these problems with fast and easy method such as finite element method, limit equilibrium method and artificial neural network.



Figure 1.1 Photo of Weand earth dam (Ministry of Water Resources in Iraq, 2011)

Thus slope stability should be evaluated to determine whether a proposed slope required more safety and performance criteria during design. The stability of slopes of cohesive soil is an important characteristic for this kind of dams, landfills, earth moving and excavation. It is mostly influence by the soil strength parameters "cohesion (c), angle of internal friction (ϕ) and unit weight (γ)", in addition influence by pore-water pressure and geometry of slope. The performance of a slope for earth dams and slope soils its susceptibility to failure is usually determined by the safety factor (F) (Lambe and Whitman, 2012).

1.2 Importance of the Study

The one of the important problems in slope stability analysis are determining the factor of safety (F), because earth dams (such as homogeneous dams) are exposed different types of failures, especially for upstream slope of dam when it reaches the maximum height phase and also for drawdown of the water level, as shown in Figure 1.2. Therefore this issue needs an increasing of the knowledge to protect these types of dams failures.



Figure 1.2 Failure of the upstream slope for Salma earth dam(Hamid,2002)

The danger of dam in its collapsing occurred if it is not built according to certain engineering and geological fundamentals leads to the destruction shown in Figure 1.3



Figure 1.3 Teton earth dam collapsed(Perrow,1984)

The collapse of the dams causes many risks to society like floods that lead to the destruction of the regions located in the downstream of the dam such as cities, rural areas, soil erosion and spread diseases as a result of

water pools therefore it must be taking into consideration the geological studies that include many factors.

Many earth dams expose collapses in the end of constructions full reservoir and discharge operation. These collapses occur when the magnitude of (F) is less than critical assigned values of its, and mainly depending on soil strength parameters (c , ϕ and γ), as well as slope height.

Therefore, the assessment of (F) is important issues to know the sensitivity of the failure for the upstream slope of the earth dam using any methods for slope stability prediction to assessment (F) such as (LEM, FEM and ANN). For this reason, the relationship studies between the factor of safety and these parameters is important to prevent those collapses.

1.3 Problem Statement

There are a lot of studies deal with the study of slope stability for the earth dams by the influence of some factors such as :soil strength parameters, pore water pressure, earthquakes and some surcharge loads. While these studies do not cover all expected issues that appear in many dams, for example studying the changes in water levels on safety expect. In addition, there are a few researches that take into account the comparison of results obtained from LEM and FEM. Finally, there are very little studies use ANN for this type of problems, thus more studies are needed to cover all issues. Therefore this study takes into account these factors to investigate the factor of safety of earth dams under different conditions.

1.4 Objectives of the Study

The objectives of this study are:

- 1- Studying the slope stability for suggested and actual earth dams using different methods LEM, FEM and ANN.

- 2- Studying the influence of limitations factors to slope stability response.
- 3- Assessing the slope response using proposed method based on Artificial Neural Network (ANN) method.

1.5 Thesis Outline

The arrangement of this thesis has been prepared in five chapters and four appendices. The introduction of the dams and slope stability problems is presented in chapter one. A literature review of slope stability assessment is detailed in chapter two. Chapter three included both limit equilibrium (LE) methods and finite element (FE) method for (F) determination. In addition to software programs and Artificial Neural Network (ANN) are presented in this chapter. Results and discussion that obtained from this study which including tables and figures are presented in chapter four. The conclusions and recommendation are presented in chapter five. Appendix (A) included hand calculation Appendix (B) contain results of LEM and FEM. Appendix (C) included cross-sections of critical slip surface for analysis of earth dams with and without water level and Appendix (D) included code for (ANN) .

ABSTRACT

Behavior of Slope Stability for Earth Dams

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In fact the earth dams in civil engineering are important projects and directly influence on economic system of communities. Usually used to store the water for various purposes during the time. For this reason, countries concern on protecting them and keeping them from the risk of collapse. Scientific studies continue to evaluate safety factor for the slope stability of earth dams, by influencing number of the factors (i.e. soil properties and pore water pressure). Therefore, the current thesis aimed to study the influence of soil strength parameter for dam body (i.e. cohesion, angle of internal friction and unit weight of the soil) on the performance of dam. In addition, the effect of various height of earth dam with different levels water in the reservoir as well as rapid drawdown for the water level on slope stability performance of earth dams. These objectives were achieved by calculated the factor of safety for two types of earth dams (i.e. suggested earth dams and actual earth dams) using (Geo-studio) software based on limit equilibrium methods and finite element method. The results are adopted in this assessment by (Morgenstern-price) method. Finally, this study also included a proposed prediction of slope stability using artificial neural network ANN. This method represents a new application for this type of study and can be used for any other types of earth dams. It can be concluded that, the stability of upstream of earth dams is increased by the increasing of the values of (cohesion and angle of internal friction) in the case of dry condition that the average percentage of increasing the value of factor of safety ($F_{\text{increase}}=60\%$) at ($\gamma=16\text{kN/m}^3$) and this value decrease to ($F_{\text{increase}}=56.8\%$) at ($\gamma=21\text{kN/m}^3$) for different values of c , ϕ and increase the slope angle. In addition increase the value of (F) when increase the water level in the reservoir, and decreased with the increase of the height of earth dam and the unit weight of the soil that the average percentage of increasing the values of factor of safety ($F_{\text{increase}} = 13.43\%$) when ($\gamma=16\text{kN/m}^3$) and becomes ($F_{\text{increase}} = 8.71\%$) when ($\gamma=21\text{kN/m}^3$), as well as when rapidly drawdown of the water level in the reservoir. In addition, the method of slope stability prediction using ANN is faster and easier in comparison with other traditional methods and can obtain accurate results for calculation the values of factor of safety, when ($H=7\text{m}$) the value of ($F_{\text{MI}}=2.196$) and predict value by model(ANN) ($F_{\text{ANN}}=2.1955$) for constant values (c , ϕ , γ).