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Study on Anfis Prediction for Slope Stability

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ABSTRACT

In this research, Adaptive Neuro Fuzzy Inference System (ANFIS) was used to predict the stability of slopes. SLOPE/W, software was used to calculate the safety factor using limit equilibrium method. The general formulation of the software could analyze slope stability using various methods i.e. Morgenstern-Price, Janbu, Bishop and Ordinary to calculate the safety factors. After analyzing, ANFIS was used to predict the slope stability. Several important parameters such as height of slope (H), unit weight of slope material (γ), angle of slope (θ), coefficient of cohesion (c) and internal angle of friction (ϕ) were used as the input parameters, while the slope stability was the output parameter. A model to test the stability of the slope was generated from the calculated data. Results showed that the prediction was accurate and close to the target data.

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INTRODUCTION

Slope stability problem has been an important issue in geotechnical engineering. The evolution of slope stability analyses in geotechnical engineering has followed closely the developments in soil. It needs a better prediction and monitoring of its parameters in order to design a more stable slope. ANFIS has been used to predict variable parameters for different designs of slope (Lee, W.A., 2002; Edwin, J., S. Kumanan, 2007). In this study, factor of safety (FoS) for 300 designs of slopes was calculated by using four methods of analyses i.e. Morgenstern-Price, Janbu, Bishop and Ordinary.

Slope stability is typically evaluated in terms of FoS. FoS is a ratio between resisting and driving forces. It follows that if shear strength is greater than shear stress, then FoS > 1 and the slope may be considered stable; if shear strength is less than shear stress, FoS < 1 and the slope may be considered unstable. For FoF = 1, the slope would be considered in a balanced state, but inherently unstable (Ritter, J.B., 2004).

ANFIS serves as a basis for constructing a set of fuzzy 'if-then' rules with appropriate membership functions to generate the stipulated input-output pairs. Here, the membership functions are tuned to the input-output data so that excellent results are possible. Fundamentally, ANFIS is about taking an initial fuzzy inference system (FIS) and tuning it with a back propagation algorithm based on the collection of input-output data. The basic structure of FIS consists of three conceptual components; (1) a rule base which contains a selection of fuzzy rules, (2) a database which defines the membership functions used in the fuzzy rules, (3) and a reasoning mechanism which performs the inference procedure upon the rules and the given facts to derive a reasonable output or conclusion (Kurian, C.P., 2006).

From previous studies, an artificial neural network (ANN) is designed to do the slope stability analysis for a particular study area in Noabad, Mazandaran, Iran. 80% of the data used for the training and the remaining for validating the prediction capability using the best run of each case. From that study, artificial neural network results are considerably closer to the value calculated by the Bishop's classical method. In all cases, it is over 92% and in most cases, it is over 95% (Choobbasti, A.J., 2009).

Current computer program enables us to investigate and work on most difficult problems of slopes. In spite of this, buy that computer program is very expensive and needs time and effort from engineers to use it. To assist new users and young engineers make decision, this study focuses on prediction of safety factors.

Experimental Procedure:

Data used in this study were 300 different designs of slope. The input parameters for those designs included height of slope (H), unit weight of slope material (γ), angle of slope (θ), coefficient of cohesion (c) and internal

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angle of friction (ϕ). The experimentation for this study could be divided into four steps; (Lee, W.A., 2001) designing for different slopes. To build the slopes, a number of choices were looked at for the input parameters by fixing a number of them and switching the other ones, (Choobbasti, A.J., 2009) calculating the FoS by using SLOPE/W software. After creating the suitable geometries and input variables, LEM i.e. Bishop, Janbu, Morgenstern-Price and Ordinary were adapted to calculate the safety factor for 300 various designs, (Ping, K.Z., Q.C. Zhi, 2009) using ANFIS to predict the result. The numbers of applied MFs were three for any input and Sugeno fuzzy model was used for getting fuzzy inference system (FIS). Besides that, linear output and 243 rules were used for producing FIS. For training the FIS, 60 epochs, hybrid technique and zero errors tolerance were considered, (Vector, Y., 2008) and building a model to test the stability of the slope generated from calculated data. GUI application was developed to display the relationship between the input parameters and the output parameters of safety factors as presented in Fig. 1.

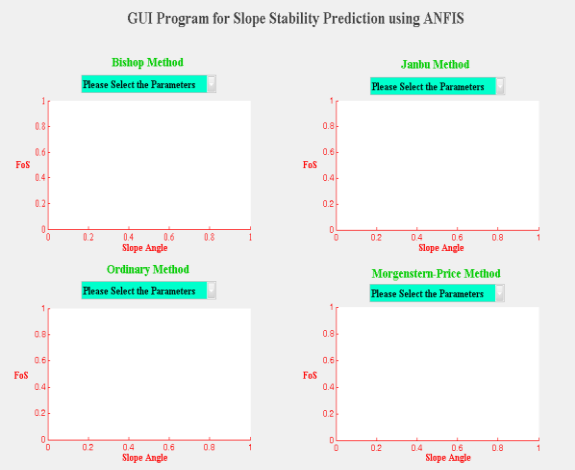

Fig. 1: GUI program for slope stability prediction.

RESULT AND DISCUSSION

By using 300 training data, ANFIS model was used as a function of different parameters. Various parameters of the ANFIS training were tested to obtain high accuracy. To build the fuzzy inference system, 243 rules were used.

At 60 epochs, ANFIS obtained training error of 0.096 for Bishop, 0.226 for Janbu, 0.095 for Morgenstern-Price and 0.091 for Ordinary. The predicted values using ANFIS and the calculated values using SLOPE/W were presented in Fig. 2 until 5 for Bishop, Janbu, Morgenstern-Price and Ordinary, respectively. Two horizontal lines were plotted to represent the stable state of slope. The result seemed that ANFIS could predict the FoS with high accuracy compare with other methods that used for predicting the safety factors for slopes i.e. ANN.

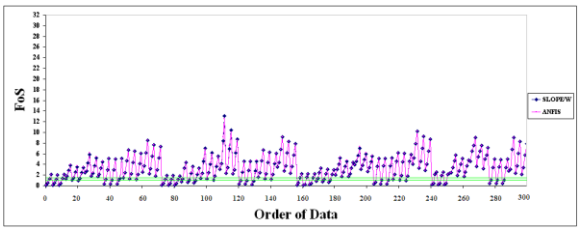

Fig. 2: Factor of safety calculated using Bishop method and predicted using ANFIS.

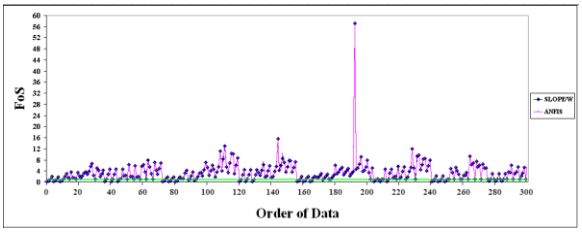

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Fig. 3: Factor of safety calculated using Janbu method and predicted using ANFIS.

Fig. 4: Factor of safety calculated using Morgenstern Price method and predicted using ANFIS.

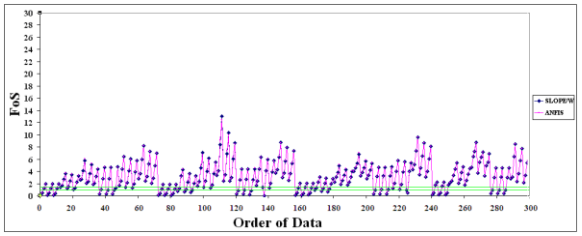

Fig. 5: Factor of safety calculated using Ordinary method and predicted using ANFIS.

Conclusion:

ANFIS was used to predict the FoS for 300 different slopes. Several important parameters such as height of slope (H), unit weight of slope material (γ), angle of slope (θ), coefficient of cohesion (c) and internal angle of friction (ϕ) were used as the input parameters, while the slope stability (FoS) was the output parameter. ANFIS training parameters were tested to get accuracy for the prediction. 243 rules were used to build the fuzzy inference system (FIS). The results showed that there was high accuracy of prediction with the calculated data. The research has shown that the stability of slopes could be successfully predicted using ANFIS with high accuracy compare with other methods i.e. ANN.

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