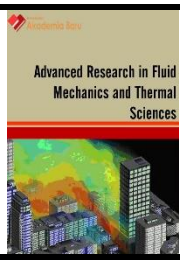
Penerbit Akademia Baru

Journal of Advanced Research in Fluid Mechanics and Thermal Sciences

Journal homepage: www.akademiabaru.com/arfmts.html
ISSN: 2289-7879



Slope Stability Prediction of Homogenous Earth Dam Caused by Fluid Particles Seeps by Using Artificial Neural Networks

Open Access

Marwah Qaddoori Majeed[1,*], Marwah Kamil Hussein[2], Mortda Mohammed[3]

[1] University of Samarra, Collage of Engineering, Civil Engineering Dept., Salah-Elden, Iraq
[2] University of Basrah, College of Computer Science and Information Technology, Computer Information Systems Dept., Basrah, Iraq
[3] Southern Technical University, Department of Mechanical, Technical Institute of Basrah, Iraq

ARTICLE INFO

Article history:
Received 17 August 2019
Received in revised form 14 September 2019
Accepted 1 October 2019
Available online 30 November 2019

Keywords:
ANN; FOS (Factor of safety); slope stability; prediction; homogenous

ABSTRACT

Artificial neural networks (ANN), neural networks or artificial intelligence, which can model complex functions. They are useful in predicting the output of two or more independent variables. Further, forecasting the stability of slopes of earth embankment is a very exciting task for civil engineers due to the geology of the region, shear strength, and groundwater of earth embankment in accessing slope constancy. In this paper, a prediction process has been developed for predicting the safety factor (FOS) of slopes by using the ANN. 243 circumstances with dissimilar arithmetical, soil factors of homogenous earth dam and different fluid heights were analysed using multilayer method. Out of these, 70% of cases were used for training the model and 30% for testing the model. The results showed that if we used 70% of testing and 30% for training with one hidden layer is the best choice with R=0.901, in contrast of using all cases with testing, which goes far away from unity.

1. Introduction

A dam can be defined as a barrier that stops and/or restricts the drainage of water or underground streams. Reservoirs that are created by dams do not only prevent floods but also provide water resource for activities such as watering, human consumption, usage, and agriculture. Generating electricity is a major usage of a dam. Moreover, a dam can also be utilized to collect water or for storage of water, which can be evenly distributed among locations. Dams serve the basic purpose of preserving water, while other structures like floodgates or levees (also known as dikes) are used to control or direct water stream into specific land areas [1].

In the reference paper [2], the authors have developed a model for estimating the slope stability of the earth-centred on the technique of ANN. For this aim, a multilayer forward-feed network by Levenberg-Marquardt learning procedure and 14 hidden-knots were engaged by means of current empirical data along with the outcomes of classic boundary equilibrium examines of 57 diverse cases as said by the pre-defined empirical plan. The obtained outcomes show a great level of numerical

* *Corresponding author.*
E-mail address: marwakad9@gmail.com (Marwah Qaddoori Majeed)

dependability (MSE = 0.0035 and R = 0.95 for examining a set of scaled numbers) and alike estimate accurateness as the current arithmetical expression for the computation of the safety factor of the slope. ANN are complicated modelling methods and are capable of modelling tremendously complex formulas. Furthermore, they are used for predicting the outcome of two or more independent variables. Predicting the stability of slopes is a very challenging task for the geotechnical engineers. Hence, they must allocate particular care to the geological surrounding, water under the ground and shear strength of the soils in evaluating slope stability [3 – 6]. In this research paper, a predictive formula was developed for predicting the FOS of the slopes by utilizing ANN. 110 cases having diverse arithmetical and soil conditions were analysed using Bishop's Simplified Method. Out of these, 100 cases were used for training up the predictive model. The computation method for the training process was a back propagation-learning procedure. The predictive model is authenticated by the comparison of the results with the remaining 10 cases [7].

Prediction of slope stability has a primary concern in the identification of the terrain, which is vulnerable to landslides and justifying the destructions that were caused by landslides. Moreover, in research [8], a classifier of Naive Bayes (NBC) was utilized to forecast the constancy for a slope exposed to rounded disappointments, and is established on six input elements: angle of slope (α), slope of height (H), angle of friction (φ), consistency (c), weightiness of unit (γ), and pore compression rate ($r\,u$). An anticipation of optimization procedure was utilized to complete variable-learning process for the NBC through an unfinished data group of 69 cases of slope. The authentication model with 13 different cases states that, as associated to the current experimental approach, the suggested NBC model produces an improved act in terms of both accurateness and applicability (i.e. the NBC permits determining the possibility of slope stability created on any sub-set of the six input factors.

In this current research, a prediction process has been developed for predicting FOS for the slopes of the homogeneous earth dam by using ANN with one hidden layer and two hidden layers. This algorithm includes a comparison between the two methods in order to find the ultimate methodology.

2. Methodology

2.1 SLOPE/W Program

GEOSTUDIO software is one of the geotechnical programs based on the finite element scheme and can achieve studies, such as strain-stress, leakage, the stability of the slope, and dynamical investigation [9]. SLOPE/W (slope for Windows) is a finite element software product coming under GEOSTUDIO package can be used in analysing slope Stability. The slope stability analysis identifies the most probable failure from consideration of the shape of the slope. In other words, it would show whether the slope of the earth dam is suitable based on its design. This study also produces a proposal on how to improve slope stability [10 – 11].

2.2 Artificial Neural Networks (ANN)

An Artificial Neural Network is a segmented network of simulated nodes. The nodes or neurons are commonly settled in parallel to build partitions or layers. The head partition, which accepts the incomes or inputs, is named the input partition, and the latter partition is named the output partition. The remaining are buried partitions dependent on the issue to be answered [12-13].

The input partition receives the input amounts from the external. Hence, all the nodes of the input layer form the inputs of the neural network. The knots of the output partition are directed from

the output amounts to the user's external environment [14]. The buried partitions are the treating place of the networking structure. The loads (weights) are accustomed in a sequential system to attain the predictable output amounts. A classic simulated neural is exposed in Figure 1.

The nodes number in the head and latter partitions are adjusted based on the amount of reliant and independent parameters in the training values, although the choice of an optimum value of knots in the buried partition is subject to the problem itself. When the number of neurons is trivial in the buried partition, the system might not train the procedure properly. Instead, when the amount is very big, the train would consume an extended period, and the above-fit of the train values might occur [15].

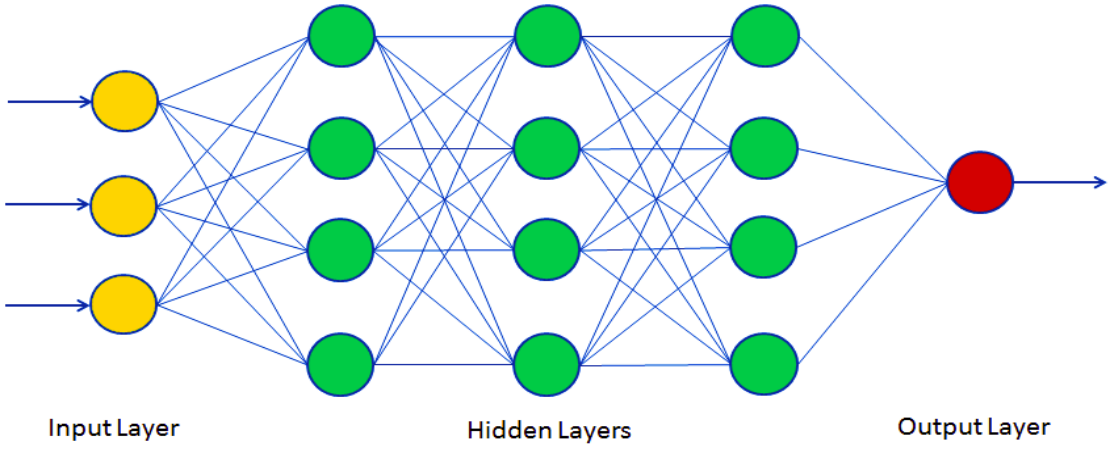


Fig. 1. Classic ANN

2.3 Approach

The homogenous earth dam is taken as a typical shape including several important parameters; (fluid)water height (H), cohesion (C), internal friction angle (ϕ), angle of slope (β) and item weightiness of soil (γ) were all used, for instance, as input values by fixing dams height with 10m, while FOS was utilized as the target value. The slope/W program was used to find FOS by using input parameters and, then, by using entry and exit method.

For finding the optimum weight combination, the network was trained up using the multi-layer method in SPSS program. The data contains two distinct sets, which are training and testing. The goal of training data is to discover the group of weightiness among the neurons that compute the universal least error formula. Moreover, the chief formula of the set of testing is to determine the general capability of an educated (trained) network, whereas the set of authentication achieves the last checking of the educated network. Training stops as the mistake of the set of the test begins to rise. For instance, among 243 cases of the slope, 70% of the values set were utilized for training, while the residual was utilized for testing and authenticating the system. Once the training process is well accomplished, the act of the educated system is authenticated. The coefficient of correlation (R) and the error of the root mean squared (RMSE) are the key standards frequently utilized to assess the forecast act of the ANN systems.

3. Results and Discussion

The present research is directed towards the parametric study of slope stability of the homogenous earth dam with different fluid heights, and it was carried out using strips method. Various fluid (water) heights, soil parameters and slopes in U/S and D/S parameters were considered. By SLOPE/W program and with entry and exit method, slip surface was eliminated in U/S and D/S to estimate the factor of safety which effected by fluid (water) partial seeps.

The regression plotting of the worth of R of train and test is depicted in Figure 2. According to the regression scheme, it was discovered that the worth of R matches 0.901 for one hidden layer (70% testing and 30% training), which is very close to unity. For two hidden layers, the percentage has a little difference of one hidden layer with R=0.89, as shown in Figure 3. The model is tested by comparing the results from prediction with the remaining cases (30%) of the results. It was found that the results of prediction have a close relationship with the actual results. The RMSE is found to be a very low value of 0.099 in one hidden layer and 0.11 in two hidden layers.

In the second case, all of the results were included in the test with no results for training. Thus, the R-values would be far away from unity, even if we used one hidden layer or two hidden layers as shown in Figure 4 and Figure 5. Hence, it can be stated that the results of prediction have to state a near correlation among the input parameters.

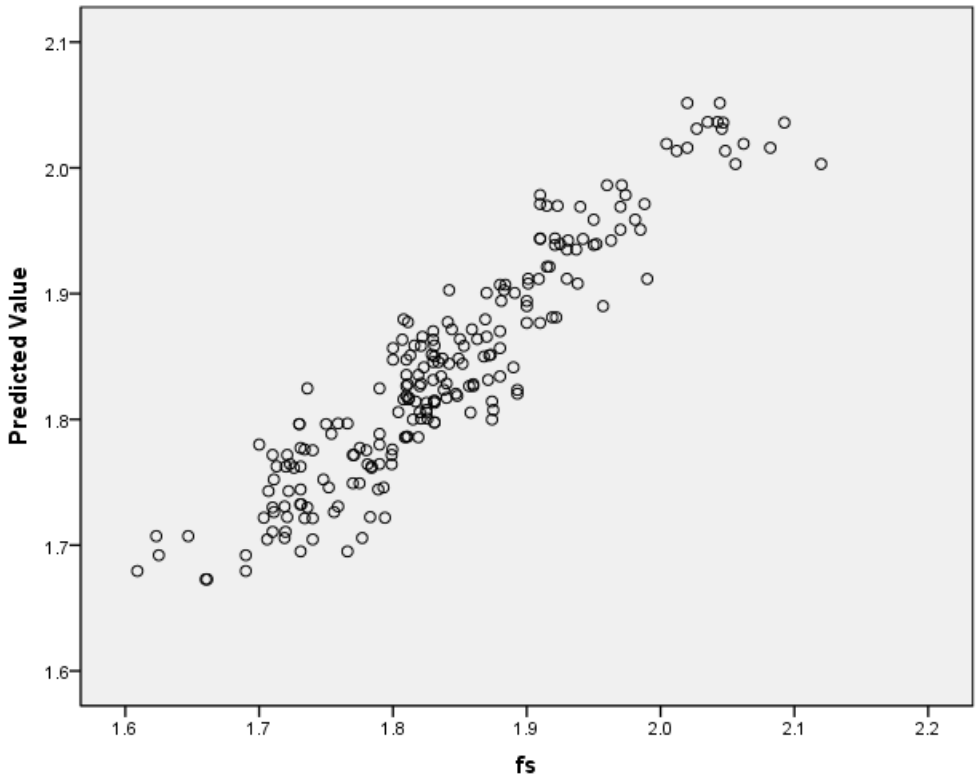


Fig. 2. Correlation between real and forecast items with (R=0.901), one hidden layer and 70% tested results

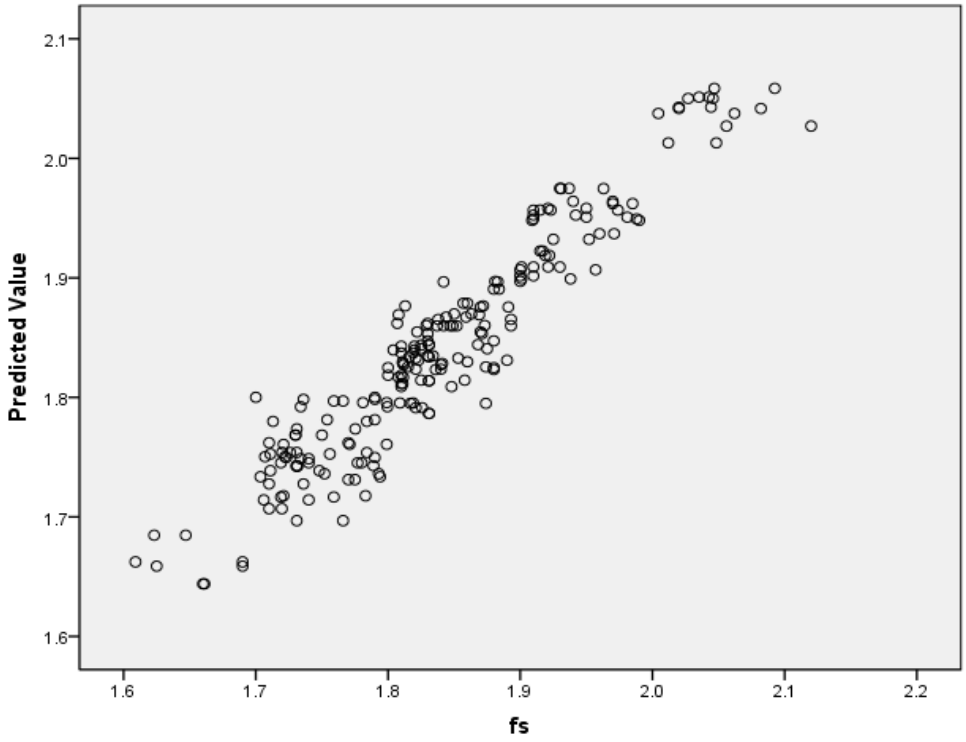


Fig. 3. Correlation between real and forecast items with (R=0.89), two hidden layers and 70% tested results

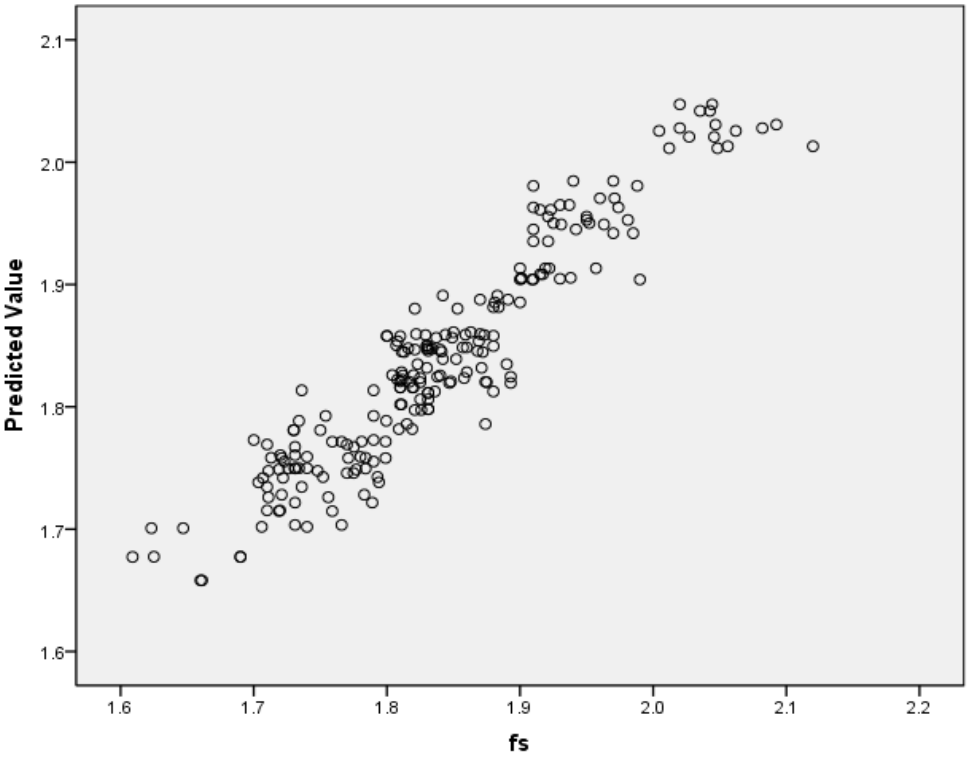


Fig. 4. Correlation between real and forecast items with (R=0.86), one hidden layer and 100% tested results

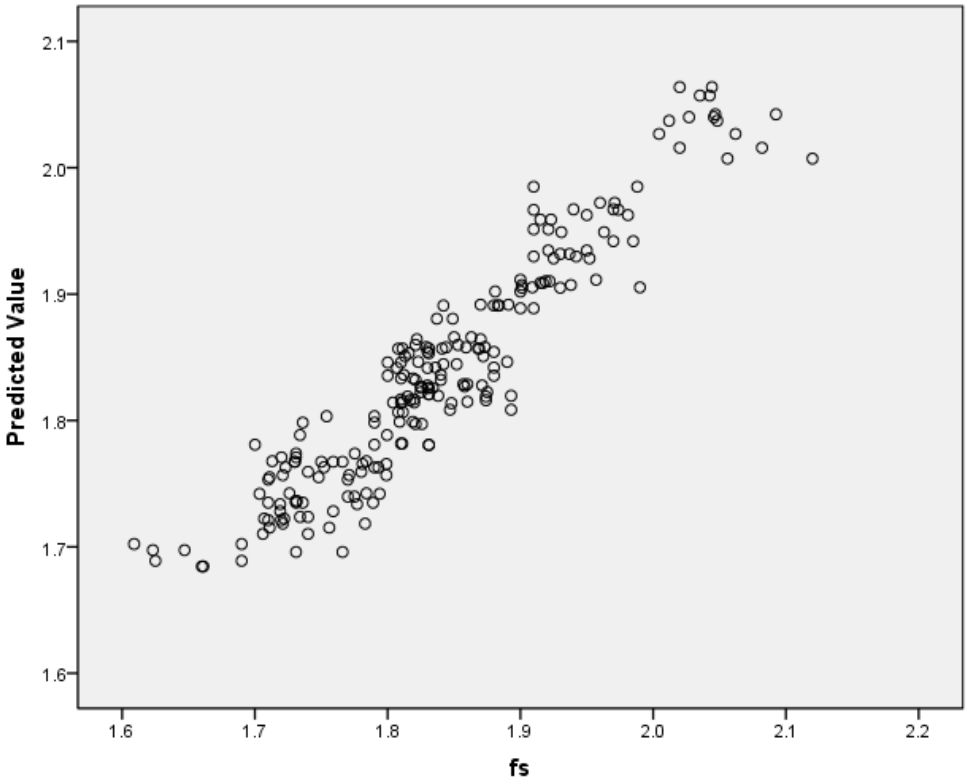


Fig. 5. Correlation between real and forecast items with (R = 0.84), two hidden layer and 100% tested results

4. Conclusions

In this research paper, 243 slopes case were analysed with slope/W software, and out of that, 70% of slope cases were used to estimate the model prediction by using ANN from SPSS software program. The researchers used two methods that are one hidden layer and two hidden layers to find the optimum outcome with a minimum error rate. Moreover, the testing of the system prediction was performed by associating the predicted outcomes from ANN with the actual results of the remaining 30% cases. From the presented research, we have been found that the predicted results from ANN give a close relationship with the actual results. Finally, it can be concluded that ANN is useful for perfect prediction modelling for earth dams slope stability analysis.

References

[1] Marwah,Q, Majeed. "Factors Affecting Slope Stabilty Analysis of Homogenous Earth Dam Using SLOPE/W and (ANN) Programs" Alutruha ,1(8), 2018.

[2] Sran Kosti, Nebojša Vasovi, Kristina Todorovi and Andreja Sam."Application of artificial neural networks forslope stability analysis in geotechnical practice." *In Symposium on Neural Networks and Applications (NEUREL) SAVA Center*, Belgrade, Serbia, November 22-24, 2016.

[3] Abramson, Lee W., Thomas S. Lee, Sunil Sharma, and Glenn M. Boyce. *Slope stability and stabilization methods*. John Wiley & Sons, 2001.

[4] Vector, Y. "Application of soil nailing for slope stability purpose." *Sc. University of Technology* (2008).

[5] Choobbasti, A. J., F. Farrokhzad, and Amin Barari. "Prediction of slope stability using artificial neural network (case study: Noabad, Mazandaran, Iran)." *Arabian journal of geosciences* 2, no. 4 (2009): 311-319.

[6] Zhou, Ke-ping, and Zhi-qiang Chen. "Stability prediction of tailing dam slope based on neural network pattern recognition." In *2009 Second International Conference on Environmental and Computer Science*, pp. 380-383. IEEE, 2009.

[7] Chakraborty, Arunav, and Diganta Goswami. "Slope stability prediction using artificial neural network (ANN)." *International Journal of Engineering and Computer Science* 6, no. 6 (2017): 21845-21848.
[8] Feng, Xianda, Shuchen Li, Chao Yuan, Peng Zeng, and Yang Sun. "Prediction of slope stability using naive Bayes classifier." *KSCE Journal of Civil Engineering* 22, no. 3 (2018): 941-950.
[9] Kachare, Jitendra, and Seema Jagtap. "Seepage Analysis of Gangapur, the Earthen Dam Using Geo-Studio Software." *International Journal of Recent Advances in Engineering & Technology* (2017).
[10] Tatewar, S. P., and Laxman N. Pawade. "Stability analysis of earth dam by geostudio software." *Int. J. civ. Eng. Technol* 3 (2012).
[11] Stability Modelling with SLOPE/W 2007 Version, Fourth Edition, November 2008.
[12] Irzooki, Raad Hoobi. "Computation of seepage through homogenous earth dams with horizontal toe drain." *Engineering and Technology Journal* 34, no. 3 Part (A) Engineering (2016): 430-440.
[13] Irzooki, Raad Hoobi, and Marwa Kaddori Majeed. "Studying the Effect of Geometry and Type of Soil on the Stability of Clover-Leaf Cofferdam." In *International Conference on Food Nutrition and Civil Engineering (ICFNCE'2015)*, Dubai (UAE), 2015.
[14] Erdurmaz, Muammer Sercan. "Neural network prediction of tsunami parameters in the aegean and Marmara Seas." Master's thesis, 2004.
[15] KİŞİ, ÖZGÜR. "Daily river flow forecasting using artificial neural networks and auto-regressive models." *Turkish Journal of Engineering and Environmental Sciences* 29, no. 1 (2005): 9-20.