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A Review on Artificial Neural Networks for Analyzing Unsaturated Shear Strength of Soil

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Abstract: Geotechnical engineering deals with soil as a material having uncertain behavior and its properties. Thus the analysis of the properties of soil is complex and time consuming. Shear strength is an important property which governs the parameters such as bearing capacity, stresses in soil etc. The analysis of the data regarding shear strength of unsaturated soils is essential from last two decades. Therefore, this paper is focusing on review on Artificial Neural Networks (ANN) for analyzing unsaturated shear strength. This complex interaction encouraged the application of Artificial Intelligence (AI) software to predict the behaviour of various geotechnical engineering applications. AI has superior predictive ability as compared to traditional methods. This has made AI a popular option in geotechnical engineering applications. ANN is a popular example of AI. The use of ANN is found predominant in analyzing the shear strength of unsaturated soils. In this paper type of soil, software used, input parameters, output parameters and statistical parameter are considered for review on artificial neural networks for analyzing unsaturated shear strength. The purpose of this paper is to review and compare the previous most relevant studies based on certain variables. Overall, ANN can be used for analyzing the shear strength of unsaturated soils.

Keywords: Artificial Intelligence, Artificial Neural Networks, Unsaturated shear strength, Root mean square error.

I. INTRODUCTION

In geotechnical engineering, the shear strength of the soil is an important engineering parameter which is certainly used in the design and inspection of many geo-environmental and geo-technical structures i.e. road foundations and pavements, earth dams, retaining walls, slope stability, design of tunnels and pile foundations. While conducting the experiments in geotechnical engineering, the analysis of data is a difficult and tedious and also a time taking work.

This complex interaction encouraged many researchers to apply AI software to predict the shear strength of unsaturated soil. Thus, it becomes mandatory to include certain software for easier analysis of data. The use of Artificial Neural Networks (ANN) has been found to be satisfactory for such type of work. This present study reviews that most of the researchers used ANN to reduce the rate of error and increase the accuracy to analyze the data and predict the shear strength of soil by using the data which is derived from the experiments such as triaxial shear test, direct shear test and vane shear test.

Overview of ANN

Artificial neural networks are also known as neural networks (NN). ANNs are computation tools that are vaguely inspired by the way human brain processes information. The design of ANN is to focus on modeling human brain and the architecture resembles the millions of neurons in human brain. It is composed of a large number of highly interconnected processing elements (neurons) working in unison to solve specific problems (Abeer Abdul et al. 2014). Similar to the brain, each synapses(also called as connection), transmits the signal from one neuron to the next neuron. In the case of an artificial neuron, the neurons receive signal, processes it and transmits the signal to the next neuron connected to it. Like the synapses in neurons in the brain, artificial neuron can transmit signals. The neurons have weights that can be adjusted accordingly during the process. An ANN model consists of various layers. These layers are input layers, hidden layers and output layers. The input parameters are fed from the input layer. An ANN model may contain one or more hidden layers based on trial and error method. The output layer gives the output. Signals travel from first layer (the input layer) to the last layer (the output layer), after traversing through multiple hidden layers.Statistical parameters such as coefficient of determination(R^2), root mean square error (RMSE), mean absolute error (MAE), standard deviation, variance account (VAF), error function (E) are used to determine the performance of various ANN model. The value of R^2 close to 1 gives the best ANN model.

The purpose of the paper is to study and compare the previous most relevant studies based on certain variables and to demonstrate the use of ANN as compared to traditional methods.

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I. OVERVIEW OF APPLICATIONS OF ANN

This section provides an overview of applications of ANN for determining shear strength of unsaturated soils. The current study is carried out using the previous most relevant studies on application in determining the shear strength of unsaturated soils using ANN. The review criteria emphasis on the following parameters: type of soil used, input parameters, output parameters, various software used (apart or along with ANN), best model, statistical parameters with values. It also shows the type of parameters which have the highest percentage of frequency and can be used for future research. The literature review reveals that various software are used extensively in application of Geotechnical Engineering. In last decade, the application of ANN is found predominant in determining the shear strength of soil over other software adopted by the researchers. Figure 1 shows the percentage of frequency of various software used to determine the shear strength of unsaturated soils where ANN has the highest percentage (57%).

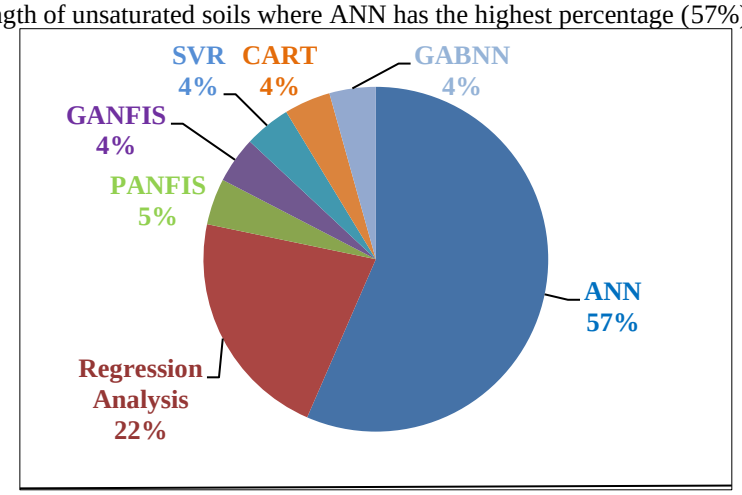

Fig. 1 Frequency of various software used

In the various research papers studied it was concluded that most of the researchers used clay as a soil type for determining various parameters and properties of soil. It was also observed that some researchers used a more than one soil in their experiments. Figure 2 shows the percentage of frequency of soils used by researchers that is reviewed in this paper where clay has the highest percentage (35%).

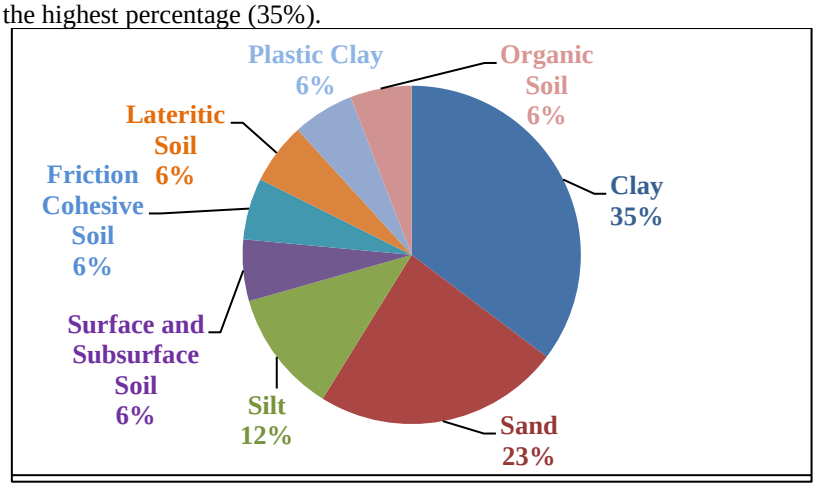

Fig. 2 Frequency of soil type

II. INPUT PARAMETERS

A variety of input combinations are used by researchers in order to obtain the desired output. The input parameters are categorized into 4 subdivisions namely Index properties, Soil type percentage, Dilatometer test data and other data. In the overall 14 papers studied 43 different input parameters were observed. Figure 3(a) shows the various index properties that were observed as input parameter in the reviewed papers. Plasticity index (PI) was the most adopted input parameter with the highest frequency of 8. Figure 3(b) shows the soil type percentage used as input parameter.

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Figure 3(c) shows the dilatometer test data as an input parameter. Figure 3(d) shows the frequency of other data as input parameters.

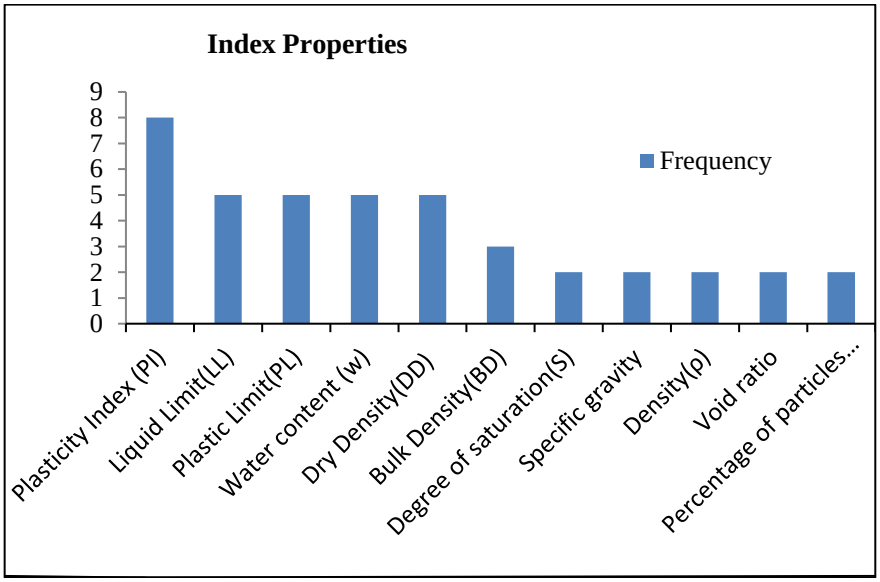

Fig. 3(a) Frequency of Index properties of soil

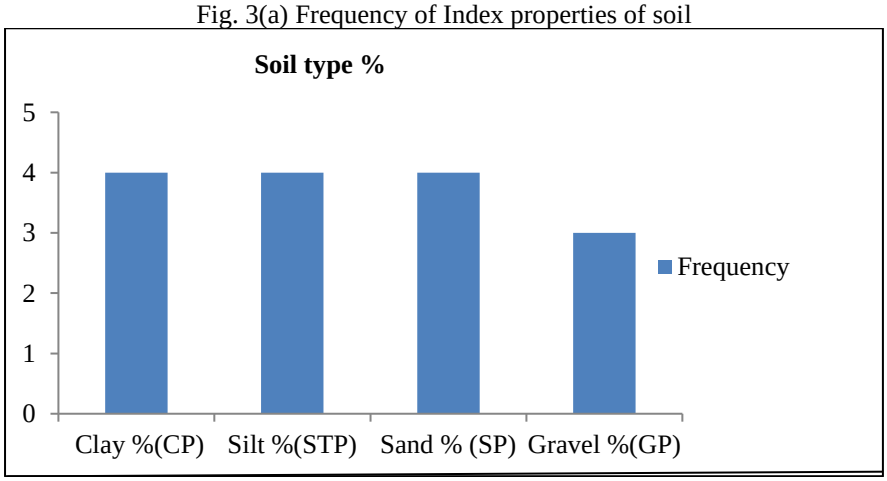

Fig. 3(b) Frequency of soil type %

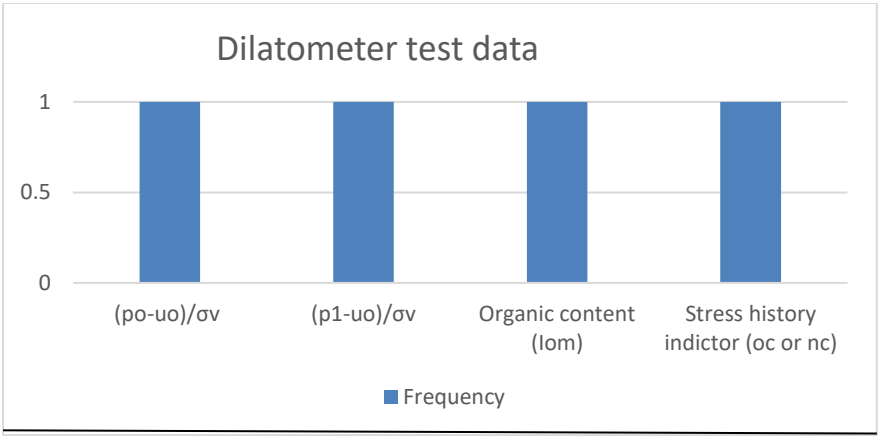

Fig. 3(c) Frequency of Dilatometer test data

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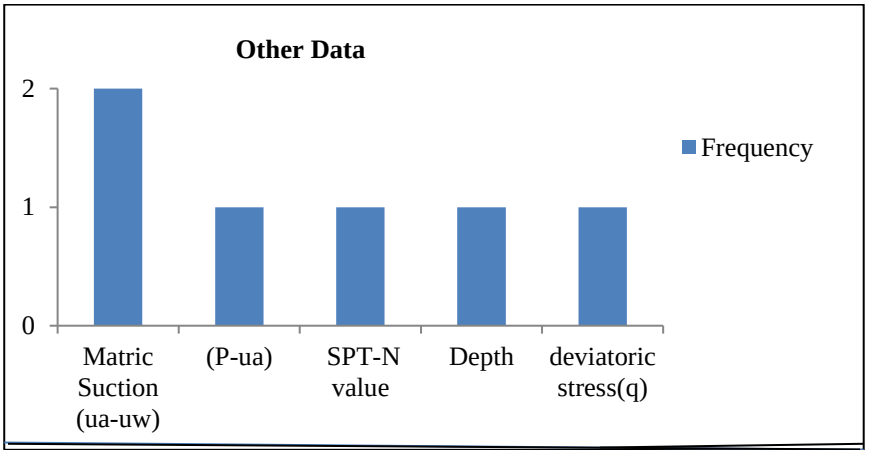

Fig. 3(d) Frequency of Other data as input parameter

III. OUTPUT PARAMETERS

After the analysis of various research papers based on the modeling on artificial neural network (ANN), it has been concluded that the frequency of the parameters i.e. Cohesion and angle of shearing resistance is maximum as the output parameters is the highest. Figure 4 shows the percentage of frequency of output parameters observed where cohesion and angle of shearing resistance give the highest percentage (65%).

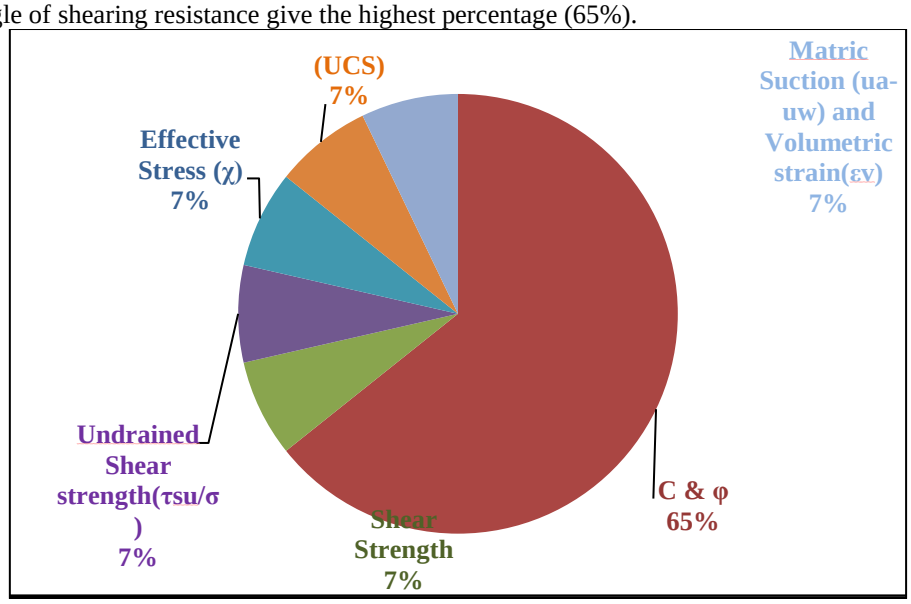

Fig. 4 Frequency of output parameters

IV. CONCLUSION

In this review paper, the importance of Artificial Neural Network (ANN) in geotechnical engineering is introduced. Specially, this software can be used exclusively for analysis of shear strength. In this paper type of soil, software used, input parameters, output parameters and statistical parameter are considered for review on ANN for analyzing unsaturated shear strength. From the data available in the literature, very few researchers have used ANN tool for analyzing the research data which are included in this study. The best ANN and statistical parameter are depicted in this paper. In the various research papers studied it was concluded that most of the researchers used clay as a soil type for determining various parameters and properties of soil. A variety of input combinations are used by researchers in order to obtain the desired output. Plasticity Index (PI) is the most adopted input parameter. The frequency of matric suction as an input parameter was found relatively less. Further studies are required to explore matric suction as an effective input parameter. The thorough study of various research papers based on the modeling in ANN concluded that the utmost used output parameters are Cohesion and angle of shearing resistance. Shear strength as an output parameter

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was adopted by only one researcher and none of the researchers adopted unsaturated condition for analyzing the shear strength of soil. Various statistical parameters and their values were also discussed indicating best ANN models. Thus, Artificial Neural Network can be used as the application for analyzing shear strength of unsaturated soils.

REFERENCES

[1]. Gunaydin, O., Gokoglu, A., &Fener, M., "Prediction of artificial soil's unconfined compression strength test using statistical analyses and artificial neural networks", Advances in Engineering Software, 41(9), 2010, 1115-1123.
[2]. Johari, A., Javadi, A. A., &Habibagahi, G., "Modeling the mechanical behaviour of unsaturated soils using a genetic algorithm-based neural network", Computers and Geotechnics , 38(1),2011, 2-13.
[3]. Ajdari, M., Habibagahi, G., & Ghahramani, A., "Predicting effective stress parameter of unsaturated soils using neural networks", Computers and Geotechnics, 40, 2012, 89-96.
[4]. Khanlari, G. R., Heidari, M., Momeni, A. A., & Abdilor, Y., "Prediction of shear strength parameters of soils using artificial neural networks and multivariate regression methods", Engineering Geology, 131, 2012, 11-18.
[5]. Kakarla, P., Sharma, S., Kanungo, D. P., Pain, A., & Anbalagan, R., "Artificial Neural Network approach based indirect estimation of shear strength parameters of soil", In Proceedings of Indian Geotechnical Conference, December, 2013, (pp. 22-24).
[6]. Kanungo, D. P., Sharma, S., & Pain, A., "Artificial Neural Network (ANN) and Regression Tree (CART) applications for the indirect estimation of unsaturated soil shear strength parameters", Frontiers of earth science, 8(3), 2014, 439-456.
[7]. Abeer Abdul, Jabber Abdul Abbas & Y.K. Bind, "Estimation of Shear Strength Parameters of soils using ANN technique", International Journal of Civil, Structural, Environmental and Infrastructure Engineering Research and Development (IJCSEIERD)ISSN(P): 2249-6866; ISSN(E): 2249-7978Vol. 4, Issue 3, Jun 2014, 1-10.
[8]. KIRAN, S., & LAL, B., "ANN based Prediction of Shear Strength of Soil from their index properties", Scopus Compendex and Geobase Elsevier, Geo-Ref Information Services-USA, List B of Scientific Journals, Poland, Directory of Research Journals ISSN 0974-5904, Volume 08, No. 05, 2015.
[9]. Iyeke, S. D., Eze, E. O., Ehiorobo, J. O., &Osuji, S. O., "Estimation of shear strength parameters of lateritic soils using artificial neural network", Nigerian Journal of Technology, 35(2), 2016, 260-269.
[10]. Kiran, S., &Lal, B., "Modelling of soil shear strength using neural network approach", Electronic Journal of Geotechnical Engineering, 21, 2016, 3751-3771.
[11]. Pham, B. T., Hoang, T. A., Nguyen, D. M., & Bui, D. T., "Prediction of shear strength of soft soil using machine learning methods", Catena, 166, 2018, 181-191.
[12]. Lechowicz, Z., Fukue, M., Rabarijoely, S., &Sulewska, M. J., "Evaluation of the undrained shear strength of organic soils from a dilatometer test using artificial neural networks", Applied Sciences, 8(8), 2018, 1395.
[13]. Elham Amiri Khaboushana ,Hojat Emamia, Mohammad Reza Mosaddeghib, Ali Rrza Astaraeia, "Estimation of unsaturated shear strength parameters using easily-available soil properties", Soil & Tillage Research 184,2018, 118–127.
[14]. Mohammadi, M., Fatemi Aghda, S. M., Talkhablou, M., & Cheshomi, A., "Prediction of the shear strength parameters from easily-available soil properties by means of multivariate regression and artificial neural network methods", Geomechanics and Geoengineering, 2020, 1-13.