ISSN (e): 2250 – 3005 || Volume, 13 || Issue, 4|| Jul.-Aug. – 2023 ||
International Journal of Computational Engineering Research (IJCER)

ANN approach for predicting the soil compaction parameters

[1]Anusha B Rao,
[1]Assistant Professor,
Department of Civil Engineering,
Alva's Institute of Engineering and Technology, Moodbidri
Mangaluru, India

[2]Vinay B Gudial, [3]Sheetal P Talakeri, [4]Shilpa Naik, [5]Ranjan Rao
[2,3,4,5] Undergraduate,
Alva's Institute of Engineering and Technology, Moodbidri
Mangaluru, India.
Corresponding Author: Anusha B Rao

ABSTRACT

Currently, the investment in India undergoes a rapid-building phase concerning the construction of various massive engineering projects. As a result heavy constructions and earthworks continue to inflate; various geotechnical engineering problems are also demanding the concern from engineers and geoscientists. Thus, the reliability of such structures considering saving of both cost and time are of great significance which must be taken into engineering and geoscientists considerations. Consequently, geotechnical data may substantiate our demands to create a large soil database covering most of the area in India. Artificial Neural Networks are apt to fulfill this approach. If rightly applied, it will minimize the investigation program by intensified ground coverage and optimizing the laboratory's testing. Experiential relationships are of greater importance in geotechnical engineering and are often used to estimate certain engineering properties of soil, using data from extensive laboratory or field testing, and these correlations are usually derived with the aid of statistical methods. In the past few years ANN's are becoming more reliable than statistical methods due to their special attributes of identifying intricate systems when the input and output are known from either laboratory or onsite experimentation. The present study aims at predicting soil compaction parameter based on out from the ANN prediction model. The result shows that the developed ANN model was very much competent enough to predict the data with fair degree of accuracy.

KEYWORDS: *Artificial Neural Network Modeling, Finite Element Method, Simulation, Soil Compaction.*

Date of Submission: 06-08-2023 Date of acceptance: 20-08-2023

I. INTRODUCTION

In agronomy, soil compaction is a combination of both engineering compaction and consolidation. It involves a reduction in volume of the soil mass avoiding settlement, to enhance the strength of geotechnical engineering structure. Prior to compaction of soil in the site, some laboratory tests are necessary to determine their engineering properties. Amongst various properties, the maximum dry density (MDD) and the optimum moisture content (OMC) are of very much important and indicate the required density to be compacted in the field. Generally Proctor compaction test is performed to obtain the maximum dry density and the optimum moisture content of the soil to know the amount of compaction needed. The objective of compaction is to increase the bearing capacity of the soil, manage undesirable volumetric changes, changes in hydraulic conductivity, improving the stability of slopes and thus decreasing the detrimental settlement of structures [1].
Various studies have been made to know the practicability of ANN approach in different aspects of soil compaction. Suhail I.Khattab et. al. (2013) has done research on the viability of using Artificial Neural Networks to find nonlinear interactions between different soil parameters. A parametric study was made for the

three models to investigate the consequence of the input variables on the output of the model [2]. Sunil Sinha and Mian C. Wang's (2008) has done research on the practicability of using ANN prediction models which relate permeability, MDD and OMC with classification properties of the soils. The ANN prediction models were developed from the results of classification, compaction and permeability tests, and statistical analyses[3]. Mohamed Shahin Marka et. al. (2001) has done research on the feasibility of using artificial neural networks (ANNs) has increased in several areas of engineering. Particularly, how ANNs have been applied in various geotechnical engineering problems and their degree of success is demonstrated [4].

II. METHODOLOGY

The current study explores the behaviour of soil various particle size distribution, viz. clay, silt, sand and gravel. Later compaction parameters of soil viz. ODD and MDD is predicted using developed ANN model.

The determination of maximum dry density and optimum moisture content of the soil is a measure of compaction level of soils [5]. This can be measured by mainly two methods Standard Proctor Compaction Test and Standard Proctor Compaction Test. Both the tests help to determine the optimum moisture content that is required for soil to attain maximum compaction i.e., maximum dry density for performing construction. Following procedure is followed to find the Soil compaction parameter determination by Standard Proctor Test [6].

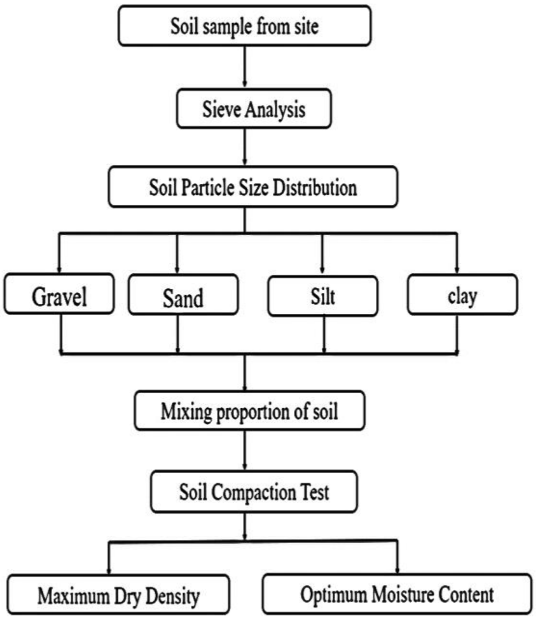

Figure: 1. Flow chart of Soil compaction parameter determination by Standard Proctor Test

A. Soil sample

The present work focuses on developing an ANN model for red soil which is the most commonly available underlying soil in India. Red soil sample for the test is collected from the surrounding of Alva's Institute of Engineering and Technology, shobhavana campus, mijar, moodabidre, at every 5mt intervals.

B. Particle Size Distribution of Soil Sample

Rock, gravel, sand, silt, clay, loam and humus are the various particles that results in formation of soil. As a result the particle size distribution or the percentage of grains of different sizes in a given soil becomes an important property of soil. Particle size analysis of coarse and fine soils is carried out by sieve analysis.

C. Mixing proportion of soil

Segregated soil sample is mixed with different percentage by varying parentage of gravel, sand and silt. Percentage of clay is kept constant.

D. Standard Proctor Compaction Test

For above mentioned 50 samples of soil with varied particle size distribution, standard proctor compaction test is performed to get the optimum moisture content and maximum dry density.

E. Artificial Neural Network (ANN)

Around 50 data sets from each parameter are considered to develop the ANN model. Data sets are divided for training and validation process in the ratio of 70:30. ANN model is developed using available software WEKA 3.9.6 by defining input and output parameters. Multilayer Perceptron neural network is used for the optimal performance of network model [7]. The number of neurons in hidden layer is set by trial-and-error method for the best performance of neural network [8].

III. RESULT AND DISCUSSION

A. Soil compaction test

We have done 50 tests using standard proctor test. We observed that from different percentage of soil sample the MDD values and OMC values are different. As the gravel content increases the density of the soil is increased. Typical Calculation of MDD and OMC for a soil sample is shown in table 1.

Table: 1. Calculation of MDD and OMC of one of soil samples

Dai of mould, cm	**10cm**				
Height of mould, cm	**12.7cm**				
Volume of mould Vc, cc	**997.46**				
Weight of mould Wc,gm	**4410**				
% Of material, gravel, sand, silt, clay	**42%**	**55%**	**2%**	**1%**	
Wt. of soil	**1260**	**1650**	**60**	**30**	**3000**
Water to add as % of dry mass of soil	**6**	**9**	**12**	**15**	**18**
Quality of water to be added in ml	**180**	**270**	**360**	**450**	**540**
Wt. of cylinder +compacted soil, W1gm	**5980**	**6041**	**6095**	**6036**	**6010**
Wt. of compacted soil, Ww=(W1-Wc)	**1570**	**1631**	**1685**	**1626**	**1600**
Wet density, Pwet=Ww/Vc g/cc	**1.574**	**1.635**	**1.689**	**1.630**	**1.604**
WATER CONTENT DETERMINATION					
Wt. of container with lid W1 gm	**0.042**	**0.042**	**0.039**	**0.048**	**0.042**
Wt. of container with lid +wet soil, w2 gm	**0.107**	**0.097**	**0.095**	**0.096**	**0.100**
Wt. of container with lid +dry soil, w3 gm	**0.102**	**0.093**	**0.091**	**0.092**	**0.095**
Water /moisture content, w=[(W2-W3)/ (W3-W1)] *100	**8.333**	**8.481**	**8.632**	**8.760**	**8.902**
DRY DENSITY DETERMINATION					
Dry density,Pdry=Pwet/(1+w) g/cc	**1.453**	**1.507**	**1.555**	**1.499**	**1.473**

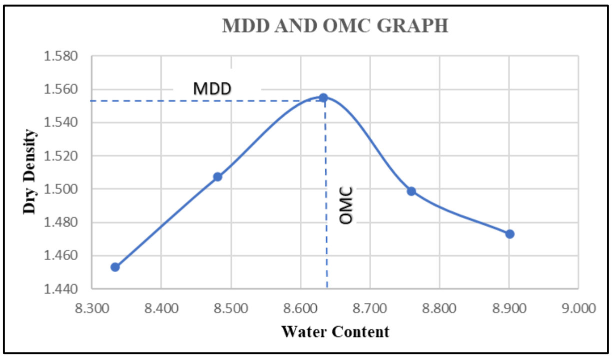

Figure: 2. MDD and OMC graph of one of soil samples

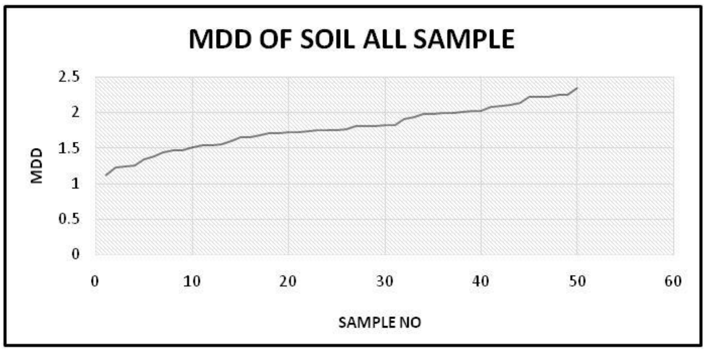

Figure: 3. MDD of all 50 samples

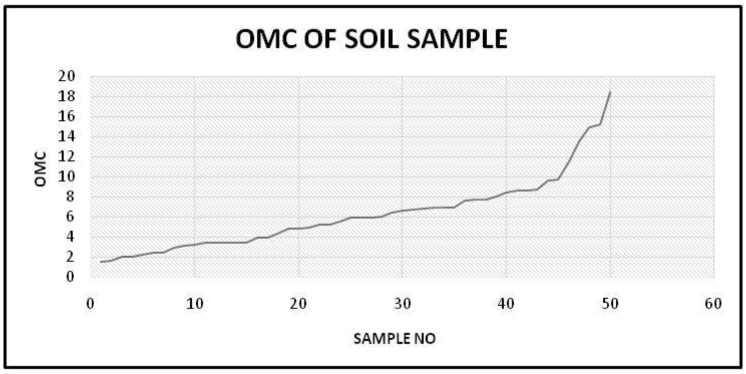

Figure: 4. MDD of all 50 samples

From the standard protector test it was observed that:
For soil proportion with gravel 30%, sand is 67%, silt and clay are 2% and 1%, the obtained MDD is 1.109gm/cc and OMC is 1.523%.
For soil proportion with gravel 49%, sand is 48%, silt and clay are 2% and 1%, the obtained MDD is 1.721 gm/cc and OMC is 4.869%.
For soil proportion with gravel 79%, sand is 18%, silt and clay are 2% and 1%, the obtained MDD is 2.341gm/cc and OMC is 18.452%.

B. ANN Module of Soil Parameter

To build ANN model for the soil samples, WEKA 3.9.6 open source software is used. From 50 soil sample test, from 100% we have divided it into 70% for calibration and 30% for validation. And data filled to WEKA 3.9.6 to build ANN model. The Performance of the ANN Model is illustrated in figures 5 & 6 and the best ANN architecture is shown in figure 7 & 8 we have entered the input data which we have got from the soil compaction test.

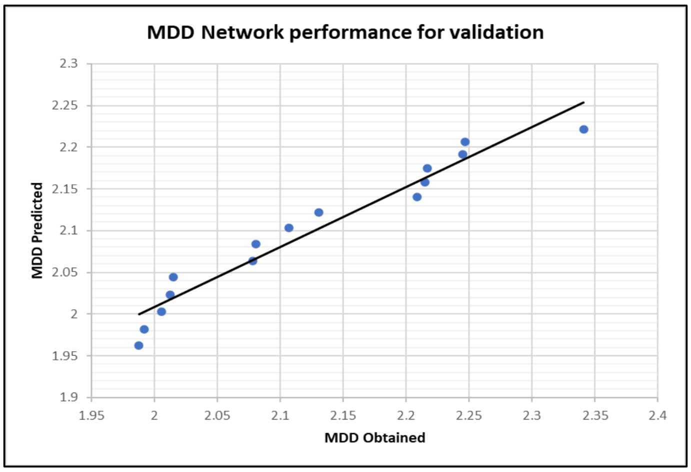

Figure: 5. MDD Network performance for validation

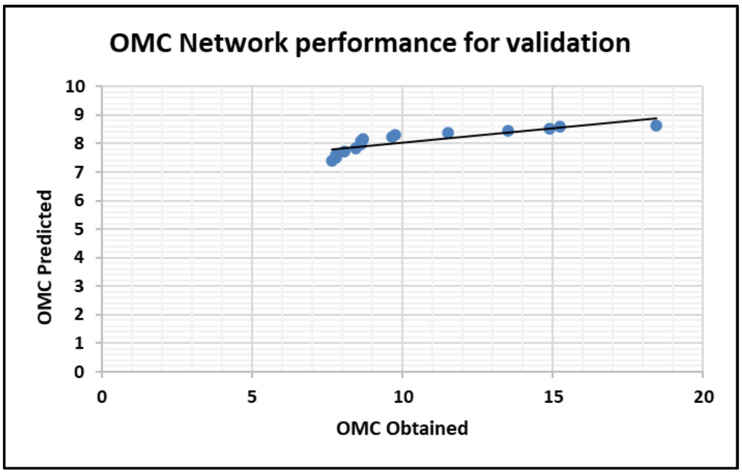

Figure: 6. MDD Network performance for validation

The observed varies predicated output values of all the parameters in scatter diagram shown that the output can be rationally well imitated by utilizing the established ANN module. ANN architecture of MDD 4-2-1 shown in fig has best outcomes for most of the consideration in modeling has best outcomes for most of the consideration in modeling of Neural Network of with Coefficient of correlation as = 0.9735, and Root mean square error as = 0.0521.

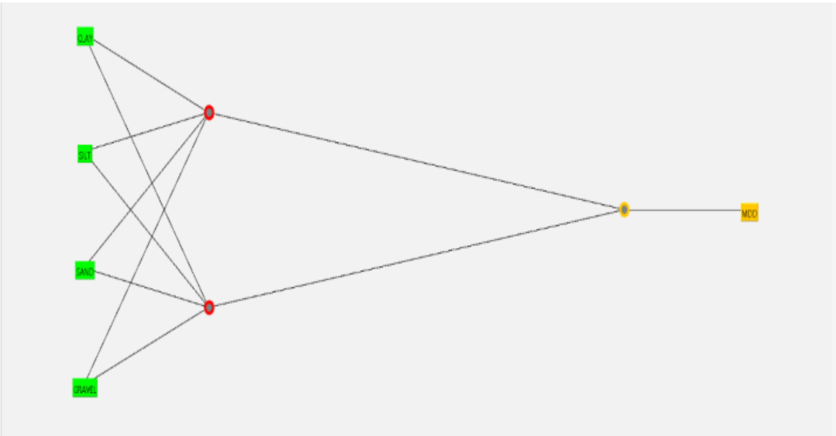

Figure: 7. ANN model in WEKA for MDD

ANN architecture of OMC 4-3-1 shown in fig has best outcomes for most of the consideration in modeling has best outcomes for most of the consideration in modeling of Neural Network of with Coefficient of correlation as = 0.994 and Root mean square error as = 0.1885.

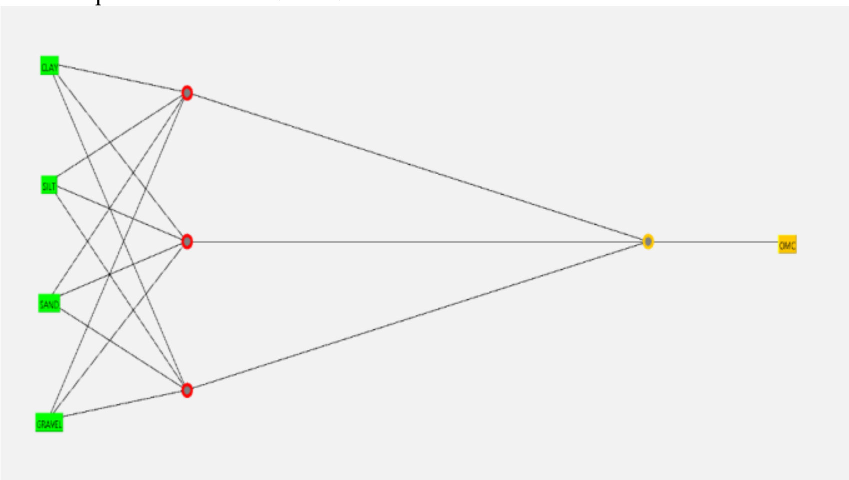

Figure: 8. ANN model in WEKA for OMC

IV. CONCLUSIONS

Within the range of data used for developing the ANN's models, they have the great potential to predict the compaction parameters with a fair degree of accuracy. Also it must be highly noted that usage of ANN's does not always assure fine outcome. From the present study based on the result observed in compaction test, it can be inferred that as the proportion of gravel in soil increase the maximum dry density increases. The study conducted over prediction of soil behavior based on particle size has shown that the artificial neural network has a capability of quick real time estimation of MDD and OMC. On the basis of output obtained from network modeling, the ANN architecture of 4-2-1 was ascertained to be apt for most of the soil parameter. The developed ANN model can be used for the initial evaluation done during the design phases and also for the feasibility studies in acquiring reliable information for site exploration projects. As result of this approach the system gives an idea about the test results before they are actually been performed leading reduced time-cost. At the same time in contrast to this it must be noted that the models is not done on pupose to void the requirement for performing laboratory tests, however it can be used as a tool to know the soil behavior based on the acquired reliable preliminary information.

ACKNOWLEDGEMENTS

The author would like to express her earnest gratitude to the second authors, reviewers and institute for proving the lab facility and encouraging this work.

REFERENCES

[1] Jayan, Jeeja and N. Sankar. "Prediction of Compaction Parameters of Soils using Artificial Neural Network." Asian Journal of Engineering and Technology, Vol.3, 2015.

[2] Yousif, Salim, "Prediction of Soil's Compaction Parameter Using Artificial Neural Network", Al-Rafidain Engineering. Vol.27, 2013, pp 15-27.

[3] Sinha, Sunil & Wang, Mian, "Artificial Neural Network Prediction Models for Soil Compaction and Permeability", Geotechnical and Geological Engineering, Vol. 26, 2008, pp 47-64.

[4] Shahin, Mohamed & Jaksa, Mark & Maier, Holger, "Artificial Neural Network Applications in Geotechnical Engineering", Australian Geomechanics, Vol. 36,2001, pp 49–62.

[5] Blotz, L. R.; Benson, C. H.; and Boutwell, G. P., "Estimating optimum water content and maximum dry unit", Journal of Geotechnical and Geoenvironmental Engineering, 1998, pp 907-912.

[6] Sivrikaya, O.; Togrol, E.; and Kayadelen C, "Estimating compaction behavior of fine-grained soils based on compaction energy", Canadian Geotechnical Journal, Vol. 45(6), 2008, pp 877-887.

[7] Tenpe, Ashwini & Kaur, Suneet, "Artificial Neural Network Modeling for Predicting Compaction Parameters based on Index Properties of Soil", International Journal of Science and Research , Vol. 4, 2015, pp 1198-1202.

[8] Mukherjee and Deshpande, M., "Modeling Initial Design Process Using Artificial Neural Networks", Journal of Computing in Civil Engineering, Vol. 9, No. 3, 1995, 194-200.