APPLICATION OF GENETIC ALGORITHM TO PREDICT DYNAMIC PARAMETERS OF GRANULAR AND COHESIVE SOILS

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Normalized shear modulus (G/G_{max}) and damping ratio (D) of soil are essential parameters for any dynamic soil structure interaction analysis. In civil engineering project, required dynamic properties are often calculated from the empirical curves. In the current study, two models are presented to predict the normalized shear modulus and damping ratio of cohesive and granular soils using Gene Expression Programming (GEP). The data used in the modeling obtained from the previous experimental studies. The input parameters include of shear strain level, confining pressure, over consolidation ratio, void ratio and grading characteristics such as uniformity coefficient. Also, the compression of the predicted and measured values of normalized shear modulus and damping ratio proposed that the models have a good performance. Lastly, the model results were compared with previous models. The results indicate that the proposed models are able to computing the dynamic parameters of cohesive and granular soils more exactly.

In order to inspect the factors of the dynamic loads on civil engineering methods, it is necessary to correctly realize soil behavior, achieve accuracy measurements and quantitative models explaining the soil dynamic parameters. There are various laboratory methods for measuring the dynamic properties. These methods can be grouped into two general categories: in situ testing such as downhole and element test methods such as torsional shear test, resonant column and wave propagation methods like ultrasonic waveforms and flexural elements (Pennington, 1999). Considering the importance of dynamic parameters of soils in dynamic analysis of the behavior of soil, many equations or curves have been presented experimentally or analytically based on the results of experiments. Due to the large volume of these relations and curves, their presentation in this section is ignored. Using these equations, we can estimate the soil parameters appropriately, without any cost or waste of time. So far, many researchers have used hyperbolic models to describe the dynamic behaviour of soils (Tolieng et al., 2017; Hardin & Drnevich, 1973). As an optimizing procedure inspired by the theory of evolvement and natural choice, GA was recognized as an accidental optimization method (Holand, 1975). In using GEP program, the amount of genes in a chromosome can be one or more and data categorization included training and validation/test, then determine the functions used and performing calculations then analyze the results (Ferreira, 2001). In fact, GEP carries out the following stages for solving any problem, 1) the process initiates by stochastic generation of chromosomes (individuals) from among a certain number of the original population, 2) the chromosomes are expressed in tree form, 3) the eligibility of each solution and its degree of adaptability with fitness function are analysed, 4) if the solution is desired, the program terminates with the current population displaying the favourable solution, if not, 5) the best present population is retained, 6) the other population is chosen based on their performance, 7) certain modifications (mutation, recombination and duplication) are made on the selected population so as to produce new children, and 8) the new born children are assessed through a cycle according to the above-mentioned conditions. This procedure recurs for a certain number of generations until the desired solution is achieved. In GEP application, the number of genes in a chromosome can be one or more. The gene consists of two types of information. The first type of information is used to generate the overall GEP model and stored in the head of the gene. The second type contains only terminals and is stored in the tail. In order to appraise the efficiency and precision of the suggested models in periods of the measured and predicted values, some statistical scales such as Root Mean Square Error (RMSE), Mean Square Error (MSE) and coefficient of correlation (R^2). In this study, models for normalized shear modulus and damping ratio of granular and cohesive soils are proposed. Equations 1 and 2 are the accurate expressions of these models aimed at valuation of dynamic parameters of soils.

$$\frac{G}{G_{max}} = \sqrt[3]{1 - (\tanh(-0.98) - \left[\left(\frac{0.31}{\gamma}\right) \times \tan PI \times \gamma\right] + \tanh(\gamma + (-\sqrt{\gamma} \times \tanh(PI)) +} \sqrt[3]{\tanh(\exp(PI) - (8.66 - PI))^3 + 6.19 \times \gamma} \quad (1)$$

$$D = \tanh \sqrt[3]{\tanh((\gamma) \times \tanh(C_u))/(\sigma_3'/4.95) + (PI)} \quad (2)$$

The results in Figure 2 indicate that the normalized shear modulus compared between the measured experimental versus predicted values, and Figure 3 display the damping ratio compared between the measured experimental versus predicted values.

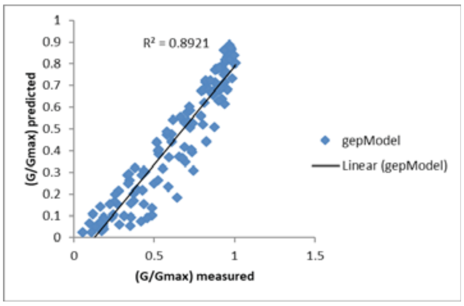

Figure 2. Comparison of the measured versus predicted values of G/G_{max}.

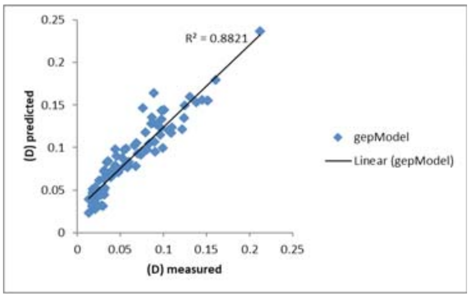

Figure 3. Comparison of the measured versus predicted values of D.

REFERENCES

Ferreira, C. (2001). Gene expression programming in problem solving. In: Roy, R., Koeppen, M., Ovaska, S., Furuhashi, T., Hoffmann, F. (Eds.), Soft Computing and Industry. Springer, UK, 635-653.

Hardin B.O. and Drnevich V.V.P. (1973). Shear modulus and damping in soils: measurement and parameter effects. *J. Terramechanics*, *9*(2), 102.

Holand, J.H. (1975). *Adaptation in Naturaland Artificial Systems: An Introductory Analysis with Applications to Biology, Control, and Artificial Intelligence*. The University of Michigan Press, USA.

Pennington, D.S. (1999). *The Anisotropic Small Strain Stiffness of Cambrige Gault Clay*, PhD Thesis, University of Bristol.

Tolieng V., Prasirtsak B., Sitdhipol J., Thongchul N., and Tanasupawat S. (2017). Identification and lactic acid production of bacteria isolated from soils and tree barks. IOS Press.