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Dynamic Elastic Modulus Estimation of Granular Soils Using Group Method of Data Handling (GMDH)

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Abstract

Elastic modulus is one of the most important parameters in geotecal engineering that is usually measured through laboratory or in situ testing. Cyclic triaxial testing is a well-known laboratory test to determine the dynamic and static parameters of soils. In the current study, the dynamic elastic modulus of sand-gravel mixture at very small strain levels (about 10^{-5}) has been studied using a triaxial cyclic apparatus along with local axial strain measurement. Influence of grading characteristics (curvature and uniformity coefficients), gravel content, mean effective confining stress and relative density on dynamic elastic modulus have been investigated. Based on the results of the tests, a comprehensive database including 120 records was established. Based on the database, two models have been developed to predict the dynamic elastic modulus using the group method of data handling (GMDH). In the first model the curvature coefficient (C_c) and in the second model the uniformity coefficient (C_u) is used as input parameter of soil grading charecteristics. Comparison of the RMSE in the two models indicates that the second model has better predictions than the first model. However, the coefficients of correlation (R) of models are satisfactory which indicates the GMDH has a good ability to predict the dynamic elastic modulus.

Keywords: *Elastic modulus, Granular soil, Cyclic triaxial test, GMDH*

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Extended Abstract:

1. Introduction

The elastic modulus is one of the important parameters in the geotechnical projects, which indicates the hardness of the materials. This parameter can be achieved by both static and dynamic methods. Dynamic elastic modulus (Ed) is one of the important parameters in seismic geotechnical projects that can be measured by in situ or laboratory measuring of the wave velocity. For this purpose, advanced laboratory testing techniques such as cyclic triaxial, resonant column and bender element have been specifically developed to study the dynamic properties of soil. So far, many studies have been done on soil hardness at various strain levels (Bayat and Ghalandarzadeh 2019; Biglari and Ashayeri 2011; Cherian and Kumar 2017; Chien and Oh 2001; Kallioglou et al. 2009; Maher et al. 1994; Zhang et al. 2005; Zhu et al. 2014). The results indicate that the parameters affecting the hardness of soil are strain level, mean effective confining stress, relative density, stress condition (isotropic or anisotropic condition), soil fabric and grading characteristics.

2. Materials and methods

A series of cylic traxial tests were performed on specimens of sand-gravel mixture under saturated conditions to investigate the influence of grading characteristics on the dynamic elastic modulus. The grain size distribution curves and maximum and minimum void ratios (emax and emin) versus gravel content for the materials are shown in Fig. 1.

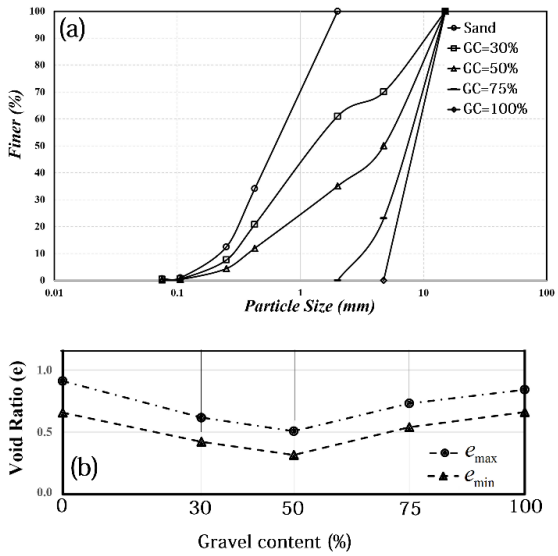

Fig. 1. (a) Grain size distribution curves of the sand–gravel mixtures (b) Maximum and minimum composite void ratios versus gravel content

3. Tests results

The elastic modulus of the specimens prepared under various conditions are presented in Fig. 2. As shown, elastic modulus increased as the mean effective stress or relative density increased. The value of elastic modulus increased as the gravel content increased up to 50% and then decreased. The

specimens containing 50% gravel recorded the highest elastic modulus at a given relative density and mean effective stress.

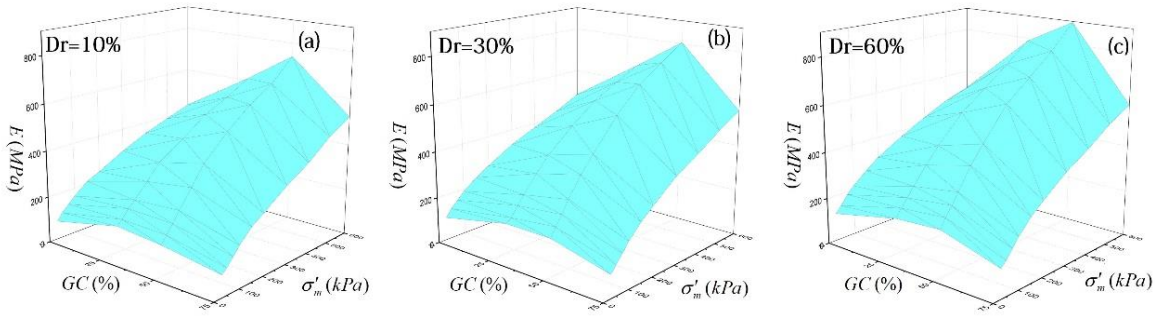

Fig. 2. Effect of gravel content and mean effective confining stress on the elastic modulus (a) Dr=10%; (b) Dr=30%; (c) Dr=60%.

Target values versus estimated ones are depcted in Fig. 3 and Fig. 4 for the first and second models. Satisfactory ability of models is observed where a coefficient of correlation above 0.9 is obtained for both models. However, the second model that uses C_u as input variable has somewhat more percision compared with the first model, indicating C_u as a more suitable parameter for estimation of dynamic elastic modulus. Thechnically, coefficient of correlation obtained by the test data is the best criterion for models comparision.

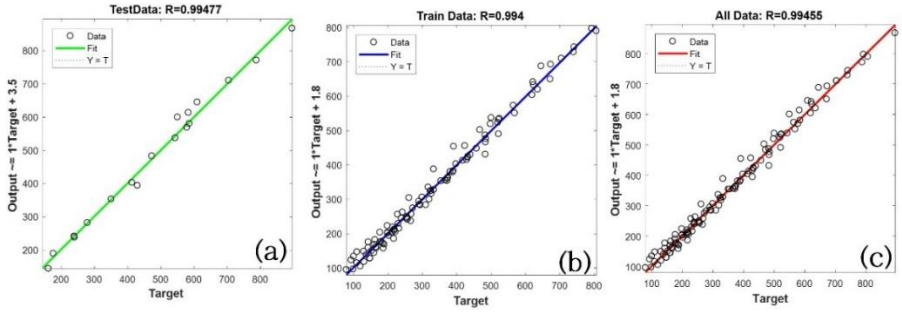

Fig. 3. Target values versus estimated values applying a) validation, b) training and c) all data for the first model

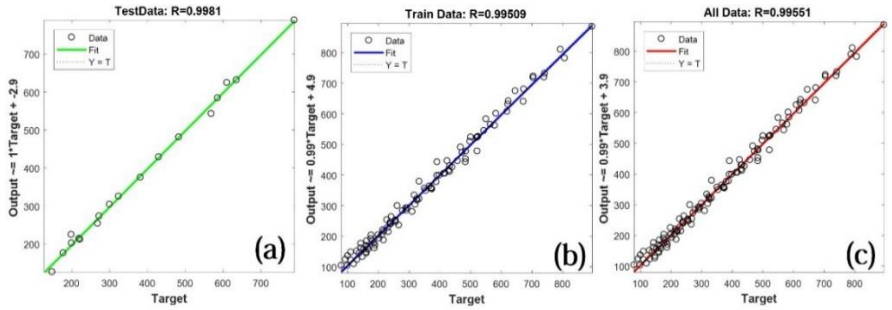

Fig. 4. Target values versus estimated values applying a) validation, b) training and c) all data for the second model

4. Conclusion

An experimental study was performed on fully saturated granular soil to investigate the effect of mean effective confining stress, relative density and grading characteristics on the dynamic elastic modulus of granular soil using cyclic triaxial testing. The test resutls indicate that, elastic modulus increased as the mean effective stress or relative density increased. The value of elastic modulus increased as the gravel content increased up to 50% and then decreased. The specimens containing 50% gravel recorded the highest elastic modulus at a given relative density and mean effective stress. Based on the results of the tests, a comprehensive database including 120 records was established. Two models have been developed to predict the dynamic elastic modulus using the group method of data handling (GMDH). In the first model the curvature coefficient (C_c) and in the second model the uniformity coefficient (C_u) is used as input parameter of soil grading characteristics. Comparison of the RMSE in the two models indicates that the second model has better predictions than the first model. However, the coefficient of correlation (R) of models are satisfactory which indicates the GMDH has a good ability to predict the dynamic elastic modulus.

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