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Unconfined Compression Strength of Soil using Gene Expression Programming

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ABSTRACT

The unconfined compressive strength (UCS) of soils is commonly used in either before and during construction of geo-structures. In the pre-design stage, the UCS as a mechanical property is obtained through a laboratory test that requires cumbersome procedures including in-situ sampling and sample preparation. In addition, these laboratory samples that are intended to simulate the field conditions constitute a significant cost for the project. Although the UCS could be obtained using prediction tools, many parameters affecting the 1D soil compression response hinder employing the traditional statistical analysis. In this study, gene expression programming (GEP) is used to overcome these limitations. Compared to other artificial intelligence-based prediction techniques, GEP has main advantage that it does not require the prior form of the existing relations to develop the prediction model. We select basic soil properties as 6 input parameters. Table 1 summarizes the prediction model which is developed using 54 training data sets sampled from 5 projects. The accuracy of prediction model is validated with the aid of 28 testing data sets from 3 projects and some statistical parameters including correlation coefficient (R), root mean square error (RMSE), mean absolute error (MAE) and relatively squared error (RSE). As shown in Figure 1, the prediction model has excellent accuracy with values of R, RMSE, MAE, RSE as 0.98,

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10.01, 7.94 and 0.03 respectively for training data whereas 0.92, 19.82, 14.56 and 0.15 for testing data respectively. From sensitivity analysis and extensive parametric studies, it is concluded that liquid limit and fine content are the most sensitive parameters whereas sand content is the least critical parameter.

Table 1. Summary of UCS prediction model established from this study.

$$UCS = A + B + C + D$$

$$A = \frac{LL}{S - PL - 0.06d - 5.68}$$

$$B = FC - \left[\frac{FC \cdot (PL - S + 0.4705)}{4.17 \cdot (S - PL - 1)}\right]$$

$$C = (S + 6.41 \cdot G_s - 25.59) + \left(\frac{1}{4.05}\right) \cdot (PL + d + 4.05 \cdot LL)$$

$$D = 6.05 \cdot LL - 146.7 - \left(\frac{4.26 \cdot d - LL \cdot d - 17.11}{d}\right)$$

Where, A, B, C and D are the expressions derived from expression trees. LL is liquid limit [%], PL is plastic limit [%], FC is fine content [%], d is depth of soil samples [m] and G_s is specific gravity of soil.

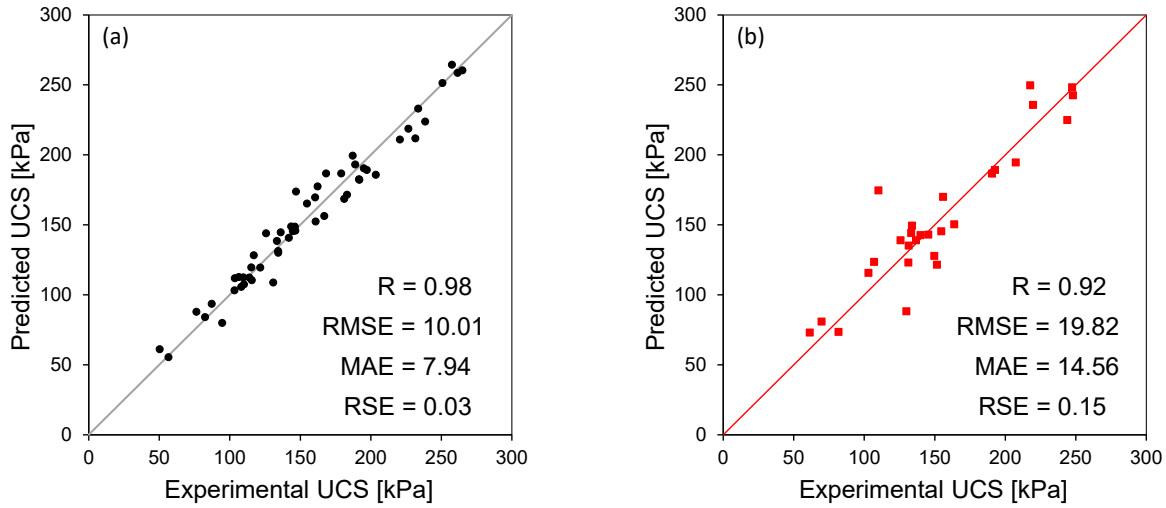

Fig. 1 Statistical analysis for comparison between experimental data and predicted model: (a) Training data; (b) Testing data. The prediction model is established by using total 82 data sets from 8 projects located in Islamabad, Pakistan.

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