Transcription Infrastructure Geotechnology (2025) 12:94
https://doi.org/10.1007/s40515-025-00552-5

TECHNICAL PAPER

Explainable Artificial Intelligence Estimation of Maximum Dry Density in Soil Compaction Based on Basic Soil Properties and Compaction Energy

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Accepted: 9 January 2025 / Published online: 8 February 2025

Abstract

The proctor compaction test is used to determine the maximum dry density (MDD) and optimal moisture content (OMC). This test can be labor-intensive and time-consuming particularly when many testing samples are involved. The forecast accuracy of the empirical correlations utilized to estimate MDD and OMC is low. The artificial intelligence (AI) models which are considered black boxes can result in trained models with high prediction accuracy and yet incoherent with physical and engineering principles. This study has thus concentrated on creating explainable AI-based models for forecasting MDD utilizing liquid limit, plastic limit (PL), gravel fraction, sand fraction (SF), clay fraction (CF), and compaction energy from a broader range of soil data as input data. Artificial neural networks (ANN), deep neural networks, support vector regression, extreme gradient boosting machine, and random forest are the algorithms used. The similarity in prediction accuracy among the five AI models serves as an example of the accuracy and reliability of AI prediction models. However, the ANN MDD model was found to be the most effective when using explainable AI (XAI) since it has a high degree of generalizability and is consistent with engineering and physical concepts in soil compaction. There were no irregular or illogical MDD estimations during these XAI analyses. PL and SF or CF have been successfully used in the creation of new XAI-based charts for direct MDD predictions as the XAI study shown that these inputs offer broader forecasts of MDD.

Keywords Artificial intelligence · Compaction · Maximum dry density (MDD) · Soil index properties · Particle size distribution

Extended author information available on the last page of the article