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Rapid Soil Classification Using Computer Vision with Electrical Resistivity and Soil Strength

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Abstract : This paper presents the evaluation of various soil testing methods such as the four-probe soil electrical resistivity method and cone penetration test (CPT) that can complement a newly developed novel rapid soil classification scheme using computer vision, to improve the accuracy and productivity of on-site classification of excavated soil. In Singapore, excavated soils from the local construction industry are transported to Staging Grounds (SGs) to be reused as fill material for land reclamation. Excavated soils are mainly categorized into two groups (“Good Earth” and “Soft Clay”) based on particle size distribution (PSD) and water content (w) from soil investigation reports and on-site visual survey, such that proper treatment and usage can be exercised. However, this process is time-consuming and labor-intensive. Thus, a rapid classification method is needed at the SGs. Four-probe soil electrical resistivity and CPT were evaluated for their feasibility as suitable additions to the computer vision system to further develop this innovative non-destructive and instantaneous classification method. The computer vision technique comprises soil image acquisition using an industrial-grade camera; image processing and analysis via calculation of Grey Level Co-occurrence Matrix (GLCM) textural parameters; and decision-making using an Artificial Neural Network (ANN). It was found from the previous study that the ANN model coupled with ρ can classify soils into “Good Earth” and “Soft Clay” in less than a minute, with an accuracy of 85% based on selected representative soil images. To further improve the technique, the following three items were targeted to be added onto the computer vision scheme: the apparent electrical resistivity of soil (ρ) measured using a set of four probes arranged in Wenner’s array, the soil strength measured using a modified mini cone penetrometer, and w measured using a set of time-domain reflectometry (TDR) probes. Laboratory proof-of-concept was conducted through a series of seven tests with three types of soils – “Good Earth”, “Soft Clay,” and a mix of the two. Validation was performed against the PSD and w of each soil type obtained from conventional laboratory tests. The results show that ρ, w and CPT measurements can be collectively analyzed to classify soils into “Good Earth” or “Soft Clay” and are feasible as complementing methods to the computer vision system.

Keywords : computer vision technique, cone penetration test, electrical resistivity, rapid and non-destructive, soil classification
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