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# Rapid Soil Classification Using Computer Vision, Electrical Resistivity and Soil Strength

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**Abstract :** This paper presents a novel rapid soil classification technique that combines computer vision with four-probe soil electrical resistivity method and cone penetration test (CPT), to improve the accuracy and productivity of on-site classification of excavated soil. In Singapore, excavated soils from local construction projects 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 labour-intensive. Thus, a rapid classification method is needed at the SGs. Computer vision, four-probe soil electrical resistivity and CPT were combined into an innovative non-destructive and instantaneous classification method for this purpose. The computer vision technique comprises soil image acquisition using 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). Complementing the computer vision technique, the apparent electrical resistivity of soil (ρ) is measured using a set of four probes arranged in Wenner's array. 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 soil strength is measured using a modified mini cone penetrometer, and w is 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 an even 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". It is also found that these parameters can be integrated with the computer vision technique on-site to complete the rapid soil classification in less than three minutes.

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

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