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Modelling and Mapping Soil Expansivity in Trinidad: Development of A Data-Driven Calibrated Free Swell Index-Based Classification Using K-Means Clustering

Presenter: Mr. Zaffir Mohammed

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ABSTRACT

Expansive soils cause significant damage to civil infrastructures, particularly in regions with limited resources for geotechnical investigations. In Trinidad these soils are abundant in the central and southern regions, which remain insufficiently quantified due to the failure to identify their existence and the magnitude of their expansion. This research addresses this problem by developing a systematic framework to classify, predict, and spatially map soil swelling behaviour across Trinidad using the Free Swell Index (FSI) as a key indicator of soil expansivity. The free swell index is a simple and cost-effective method of assessing soil expansivity, yet its application has lacked systematic calibration, limiting its reliability for engineering practice. In this study the FSI was experimentally determined for 93 locally collected soil samples, and a calibrated free swell index-based classification system for assessing the expansive potential of soils was developed using k-means clustering. Geotechnical properties such as liquid limit, clay content, plastic limit, plasticity index and soil activity were determined and used to characterise the soils' expansive potential. The optimal clustering solution (k=3) achieved an average silhouette score of 0.70, which indicates well-defined cluster separation. The resulting thresholds define four swelling potential categories based on the FSI: low (<15%), medium (15-27%), high (28-60%), and very high (>60%). The proposed classification system can be integrated into site investigations, providing engineers with a preliminary assessment that is a quicker, more economical alternative to traditional expansive soil techniques that require costly and advanced equipment, resulting in reduced risk of structural damages from expansive soils, particularly in resource-limited regions.