Project Capsule

26-3GT

October 2025

Update on Evaluating the Magnitude and Time Rate of Consolidation Settlement of Embankments and Other Piezocone Penetration Tests (PCPT)

PROBLEM

The construction of embankments and other infrastructure elements over saturated, compressible, cohesive soft soils in Louisiana presents significant geotechnical design challenges due to anticipated large magnitudes of consolidation settlement and slow rates of consolidation. Inaccurate estimation of these deformations can lead to significant differential settlements, loss of serviceability, structural damage, unsafe drivability, and increased maintenance costs. Therefore, accurate assessment of infrastructure settlement behavior and reliable estimation of the different consolidation parameters, such as constrained modulus (M), compression and recompression indices (C_c & C_r), horizontal and vertical coefficients of consolidation (C_h, C_v), and over consolidation ratio (OCR), are essential for the design and long-term performance evaluation of different infrastructure elements in such conditions.

Traditionally, the consolidation parameters are derived from laboratory tests conducted on "assumed" undisturbed Shelby tube samples, such as one-dimensional oedometer tests. However, these tests are time-consuming, costly, and suffer from certain sample disturbance and scale effects, which limit their ability to reflect the actual in-situ field behavior accurately. Additionally, the laboratory-derived consolidation parameter cannot reflect the in-situ stress and drainage conditions in the field. Recent advancements in in-situ testing, specifically the Piezocone Penetration Tests (PCPTs) and Piezocone Dissipation Tests (PDTs), offer an efficient and non-destructive method for obtaining continuous, high-resolution profiles of subsurface soil conditions, including real-time pore pressure response and strength behavior.

The results of PCPTs performed under in-situ stress and drainage conditions, complemented by dissipation tests conducted at different depths, can be interpreted for stratification and soil classification, evaluation of strength parameters, and estimation of key consolidation parameters, including M, C_c, C_r, C_v, C_h, OCR, and possibly the secondary compression index (C_a). These interpretations, however, depend on empirical or semi-empirical correlations that always require local validation and calibration, especially under Louisiana's unique subsurface soil conditions.

Start Date
November 1, 2025

Duration
36 months

Funding
SPR: TT-Fed/TT-Reg - 5

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OBJECTIVE

The primary objective of the proposed study is to utilize PCPTs and PDTs to evaluate the different consolidation parameters of fine-grained cohesive soils, including: constrained modulus, M; compression index, C_c; recompression index, C_r; coefficients of consolidation, C_h and C_v; over consolidation ratio, OCR; and possibly secondary compression index, C_a. This evaluation will be used to calculate the magnitude and time rate of consolidation settlement of embankments and other infrastructure elements built over saturated, compressible, cohesive soft soils in Louisiana. Other objectives include exploring methods and techniques for mitigating the total and differential settlements for approach embankments, as well as the effect of embankment settlement on the ultimate capacity of nearby driven piles (down drag, etc).

METHODOLOGY

The following eleven (11) tasks are proposed to meet the research objectives:

- **Task 1 –** Conduct Literature Review
- **Task 2 –** Identify project sites for conducting in-situ PCPT/PDTs, in parallel with soil borings and laboratory results
- **Task 3 –** Conduct comprehensive laboratory tests to evaluate the reference measured strength and consolidation parameters
- **Task 4 –** Evaluate available PCPT/PDT interpretation methods for their ability to estimate the strength and consolidation parameters of cohesive soils and/or modify/develop new methods
- **Task 5 –** Identify, instrument, and monitor several embankment sites for verifying the best interpretation methods and any modified/new developed method(s) for estimating the magnitude and time rate of consolidation settlement
- **Task 6 –** Verify and calibrate the best PCPR/PDT-based interpretation methods and any modified/new developed method(s) for estimating the magnitude and time rate of consolidation settlement of the instrumented embankments
- **Task 7 –** Explore different methods/techniques for mitigating the consolidation settlement of embankments and other infrastructures
- **Task 8 –** Conduct FE numerical modeling and parametric study
- **Task 9 –** Explore machine learning and artificial neural network (ANN) predictive-based models to estimate the consolidation parameters and the magnitude and rate of consolidation settlement of cohesive soils from PCPT/PDTs data
- **Task 10 –** Update the visual basic program for estimating the magnitude and rate of consolidation settlement from PCPT/PDT data
- **Task 11 –** Prepare and submit Final Report

IMPLEMENTATION POTENTIAL

Upon completion of this research project, the performance of full-scale embankments constructed over soft, fine-grained soils in Louisiana will be documented and analyzed to evaluate the effectiveness of PCPT/PDT-derived consolidation parameters in predicting the consolidation settlement behavior of embankments and other infrastructure elements. Both short-term responses during construction and long-term settlements during service life will be assessed using data from field instrumentation plans. Measured settlement data will be compared with predictions obtained from PCPT/PDT-based analytical models, laboratory tests, and 3D FE simulations. These comparisons will allow for validation, refinement, or recalibration of existing interpretation methods for key consolidation parameters, such as M, C_c, C_r, C_v, C_h, and OCR (or σ'_p). Based on the findings, practical recommendations will be provided to DOTD for using PCPT/PDT data in embankment design, settlement prediction, and foundation performance evaluation.

Deliverables will include region-specific correlations, updated geotechnical design parameters, and recommended interpretation procedures tailored to Louisiana's soft soils. To ensure successful implementation, training materials and user-friendly guidance will be developed for DOTD engineers, including instructions on integrating PCPT/PDT-based consolidation parameters into numerical workflows. This implementation phase will support the adoption of research outcomes into routine geotechnical design practices, contributing to more reliable, cost-effective, and resilient infrastructure throughout the state.