

# JOINT TRANSPORTATION RESEARCH PROGRAM

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**Sponsor:** Indiana Department of Transportation, 765.463.1521

SPR-4108

2021

## CPT-Based Geotechnical Design Manual, Volume 3: CPT-Based Design of Foundations—Example Problems

### Introduction

This manual provides guidance on how to use the cone penetration test (CPT) for site investigation and foundation design. The manual has been organized into three volumes.

Volume I covers the execution of CPT-based site investigations, a comprehensive literature review of CPT-based soil behavior type (SBT) charts, and several correlations for estimation of a soil variable of interest from CPT results. The volume has been organized into two chapters. Chapter 1 details the components of a CPT system, types of CPT equipment, testing procedures and precautions, maintenance of CPT equipment, and planning and execution of a CPT-based site investigation. Chapter 2 presents a compilation of correlations

for the estimation of a soil variable of interest from CPT data, and also presents a comprehensive review of the chronological development of the SBT classification systems that have advanced during the past 55 years of CPT history.

Volume II covers the methods and equations needed for CPT data interpretation and foundation design in different soil types. The volume has been organized into four chapters. Chapter 1 provides an introduction to the manual. Chapter 2 presents an overview of Indiana geology, the typical CPT and soil profiles found in Indiana, and the influence of these profiles on CPT-based site variability assessment. Chapter 3 details the methods for the estimation of limit bearing capacity and settlement of shallow foundations from CPT data. Chapter 4 describes the methods for estimation of limit unit shaft



*Inside view of CPT truck rigs.*

resistance and ultimate unit base resistance of displacement, non-displacement, and partial displacement piles and pile groups from CPT data. The design of both shallow and pile foundations is based on the load and resistance factor design (LRFD) framework.

Volume III contains several example problems (based on case histories) with detailed, step-by-step calculations to demonstrate the application of the CPT-based foundation design methods covered in Volume II. The volume has been organized into three chapters. Chapter 1 includes example problems for the estimation of optimal spacing between CPT soundings performed in line and distributed in two dimensions using CPT data obtained from the Sagamore Parkway Bridge construction site in Lafayette, Indiana. Chapter 2 contains example problems for the estimation of limit bearing capacity and settlement of shallow foundations using CPT data reported in literature for sites in the US, UK, and Australia. Chapter 3 includes example problems for the estimation of limit unit shaft resistance and ultimate unit base resistance of displacement, non-displacement, and partial displacement piles using CPT data obtained from three sites in Indiana. The predicted foundation load capacities and settlements were found to be in agreement with the measured load test data reported for these sites.

## Findings

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Not applicable.

## Implementation

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The *CPT-Based Geotechnical Design Manual* can be used to train new employees and to facilitate interaction between INDOT engineers, industry, and consultants. Specific implementation items for each volume are listed below.

### Volume I

A spreadsheet for the estimation of fundamental soil variables from CPT results was developed. INDOT engineers can use the spreadsheet on a routine basis to

interpret CPT data, generate an SBT profile, and obtain the depth profile of a soil property of interest.

### Volumes II and III

Spreadsheets for the estimation of optimal spacing between CPT soundings and CPT-based design of shallow and pile foundations were developed. INDOT engineers can use the spreadsheets on a routine basis for the design of transportation infrastructure projects in Indiana.

A relationship between cone resistance  $q_c$ , corrected SPT blow count  $N_{60}$ , and mean particle size  $D_{50}$  was developed using data reported by Robertson et al. (1983) and data obtained from 15 sites in Indiana. The relationship can be used to obtain an estimate of  $q_c$  for use in a CPT-based foundation design method when only SPT blow counts are available for a site.

A relationship between critical-state friction angle  $\phi_c$ , mean particle size  $D_{50}$ , coefficient of uniformity  $C_u$ , and particle roundness  $R$  was developed using test data reported for 23 clean silica sands in the literature. In the absence of direct shear or triaxial compression test results, the relationship can be used to obtain an estimate of  $\phi_c$  for poorly-graded, clean silica sands with  $D_{50}$ ,  $C_u$ , and  $R$  values ranging from 0.15–2.68 mm (0.006–0.105 in.), 1.2–3.1, and 0.3–0.8, respectively.

## Recommended Citation for Report

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Sakleshpur, V. A., Prezzi, M., Salgado, R., & Zaheer, M. (2021). *CPT-based geotechnical design manual, Volume 3: CPT-based design of foundations—Example problems* (Joint Transportation Research Program Publication No. FHWA/IN/JTRP-2021/24). West Lafayette, IN: Purdue University. <https://doi.org/10.5703/1288284317348>

View the full text of this technical report here: <https://doi.org/10.5703/1288284317348>

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