CPT-Based Geotechnical Design Manual, Volume 1: CPT-Based Design of Foundations—Estimation of Soil Properties

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...
resistance and ultimate unit base resistance of displace- 
ment, 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 calcula-
tions 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 opti-
mal spacing between CPT soundings performed in line 
and distributed in two dimensions using CPT data ob-
tained 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 re-
ported 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 resis-
tance of displacement, non-displacement, and partial 
displacement piles using CPT data obtained from three 
sites in Indiana. The predicted foundation load capaci-
ties and settlements were found to be in agreement with 
the measured load test data reported for these sites.

Findings

Not applicable.

Implementation

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 en-
gineers 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 de-
veloped using data reported by Robertson et al. (1983) 
and data obtained from 15 sites in Indiana. The relation-
ship 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 re-
ported for 23 clean silica sands in the literature. In the 
absence of direct shear or triaxial compression test re-
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.

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