GEO-PREDICTION 2017
EMBANKMENT PERFORMANCE USING SURCHARGE & PVD’S
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PROJECT BACKGROUND AND DETAILS

INTRODUCTION

A 14-foot tall roadway embankment is to be constructed over a period of nine days on either side of a river crossing as bridge approaches. Ground improvement involving triangularly spaced Prefabricated Vertical Drains (PVD’s) and surcharge loading was necessary to expedite primary consolidation prior to construction of the bridge abutments. Instrumented settlement platforms and inclinometer casings were installed to measure the vertical and lateral deformation of the embankment.

PROBLEM STATEMENT

Generate a time versus settlement plot of the vertical settlement at Settlement Platform #4 (SP-04) from time, t = 0 to 30 days after the start of construction. Additionally, estimate the horizontal displacement profile of Inclinometer #3 (IN-03) to at least 50 feet below the ground surface (b.g.s.).

SITE CONDITIONS

A thorough site investigation provided numerous in-situ and laboratory tests. The results of two Cone Penetration Tests (CPT) were performed near SP-04, and best described the soil profile beneath the embankment (Figure 1).

CALCULATED DISPLACEMENTS

Tavenas and Leroueil (1980) studied the performance of test embankments built over soft clay foundations, and suggested that lateral displacements of the embankment toe could be estimated from the observed vertical settlement. Their empirical relationship was used to estimate the lateral deformation of IN-03 (Figure 3b). Numerical modeling (PLAXIS 2D) was used to validate the deformation behavior of the embankment, where clay layers were modeled using Soft Soil (based on critical-state theory), and granular soils used the Hardening Soil model. The model results were very similar to the analytical solutions (explained previously). The comparison of results is illustrated in Figure 3a-b, where total vertical settlement at 30 days was estimated to be 15.2 inches.

REFERENCES


GENERALIZED SOIL PROFILE

A soil profile beneath the embankment, at SP-04, was developed from the various in-situ and laboratory tests that were provided. CPT data was used extensively to determine engineering properties of the underlying soils to a depth of 60-feet b.g.s. The soft clay layers accounted for the majority of the soil profile, where corrected cone resistance ranged from 10 to 20 tsf (Figure 1). Eight discrete soil units were identified (Figure 2) beneath the embankment and used to predict the embankment displacement behavior, using engineering properties provided in Table 1.

TABLE 1. Idealized soil profile properties.

<table>
<thead>
<tr>
<th>Depth [ft]</th>
<th>USC</th>
<th>θc</th>
<th>ρs</th>
<th>Cy</th>
<th>Ca</th>
<th>Ck</th>
<th>k0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 6</td>
<td>ML-CL</td>
<td>118.5</td>
<td>0.78</td>
<td>0.25</td>
<td>0.02</td>
<td>2.18E-01</td>
<td>3.0E-01</td>
</tr>
<tr>
<td>6 to 20</td>
<td>CH</td>
<td>98.0</td>
<td>0.87</td>
<td>2.00</td>
<td>0.32</td>
<td>0.03</td>
<td>1.4E-01</td>
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<tr>
<td>20 to 42</td>
<td>CL</td>
<td>110.0</td>
<td>0.43</td>
<td>3.70</td>
<td>0.28</td>
<td>0.03</td>
<td>7.6E-02</td>
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<tr>
<td>42 to 50</td>
<td>SP</td>
<td>122.3</td>
<td>0.50</td>
<td>4.80</td>
<td>---</td>
<td>---</td>
<td>5.0E-01</td>
</tr>
<tr>
<td>50 to 60</td>
<td>SM</td>
<td>112.3</td>
<td>0.42</td>
<td>4.20</td>
<td>0.30</td>
<td>0.03</td>
<td>1.6E-01</td>
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<tr>
<td>60 to 80</td>
<td>SM</td>
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<td>0.50</td>
<td>5.50</td>
<td>---</td>
<td>---</td>
<td>5.0E-01</td>
</tr>
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</table>

METHODOLOGY

Vertical settlement at SP-04 was calculated using a combination of modulus-based methods for non-plastic soils, and Terzaghi’s one-dimensional consolidation theory for plastic soils using discrete layers (Holtz et al. 2011). Analytical solutions presented by Yeung (1997) were used to account for the accelerated time-rate of consolidation and disturbance effects due to PVD installation. Typical values found in the literature for smear zone permeability and radial consolidation were suggested by Saye (2001) and Rollins and Smith (2012), where c0/cv = 3.0 for non-uniform clays, and k0/k = 3.0.

SURCHARGE, 4-ft

View of embankment and used to predict the embankment displacement behavior, using engineering properties provided in Table 1.

Figure 1. CPT profile near SP-04.

Figure 2. Soil profile beneath embankment.

Figure 3a. Predicted settlement at SP-04; (b) Predicted lateral displacement at IN-03.

Figure 4a. PVD dimensions, smear zone, and effective drain diameter; (b) typical PVD isometric view (Das 2011).