Determination of Silty Soil Bearing Capacity in Binzhou China

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Abstract: The characteristic values of bearing capacity of silty soil are determined on different basis in Binzhou area, which causes a great difference in actual work. Based on engineering practices, most original data are counted and calculated for standard penetration test, soil test and double bridge CPT (cone penetration test). The result shows that the bearing capacity is more accurate as concluded by in-situ test data, and also can provide a more helpful method for foundation design, which will play an active role in undertaking the specific engineering investigation work and maintaining the summary of regional empirical values.

Keywords: Binzhou area, characteristic values of bearing capacity, in-situ test, silty soil.

1. INTRODUCTION

There widely distributed is the Yellow River alluvial formation and paralic sediment with large deposition thickness in Binzhou area. The silty soil is widespread with 0-7.5 m depth and 0.5-6.2 m thickness, and can always act as a bearing layer for buildings. To determine the bearing capacity of the silty soil, both special standard penetration test data and soil test data were used. However, there existed obvious difference between the above two calculated results [1-3], causing a certain degree of interference for foundation design. Therefore, to provide more accurate basis for foundation design, and find more practical regional experience values, the authors applied the specific statistical analysis [4] to scientifically determine the bearing capacity of the silty soil.

2. BASIC CHARACTERISTICS OF SILTY SOIL IN BINZHOU AREA

674 drilling data of engineering investigation projects were chosen from four representative power plants, for civil and industrial construction in Binzhou area, where the silty soil mainly sedimented in alluvial formations. The overall characteristics are as follows:

Silty soil ($Q_{al}$), brown to dark brown, slightly tight - close grained, slightly wet - very wet, 0.5-6.2 m thickness. The physical and mechanical parameters are shown in Table 1.

3. METHODS FOR DETERMINING BEARING CAPACITY

3.1. Determining Bearing Capacity of Silty Soil by Standard Penetration Test

3.1.1. Standard Penetration Test Data Statistics

Standard penetration tests were performed for 181 times in the silty soil sediment. The results are shown in Table 2.

3.1.2. Calculation and Analysis of Statistical Data

According to the statistical results, data distribution histogram (see Fig. 1) is shown as follows:

From the results of the statistics mentioned in Fig. (1), standard penetration number mainly concentrated in the range from 3 to 6, which was about 88.9% of the total statistical data, and the proportion of 2, 7, 8 and 9 is less comparative. After calculating these data, according to the related literature [5], the variation coefficient $\delta = 0.317$, which is greater than the theoretical upper limit value of 0.3. If the numbers of 2, 7, 8, 9 are eliminated for obvious deviation, the variation coefficient $\delta = 0.239 < 0.3$ (the theoretical upper limit value of variation coefficient), then the standard value $\Phi_v = 4.215$, maximum value 6, minimum value 3 and average value $\Phi_m = 4.356$.

3.1.3. Calculating Characteristic Value of Bearing Capacity

As it was mainly alluvial plains of the Yellow River in Binzhou area, and the silty soil sediment was mainly alluvial origin [6], we refered to Technical Standard for Building Foundation (DB42/242-2003) and Base Design Criterion of Construction Foundation (DBJ15-31-2003) [7, 8], where
causes of silt soil sediment are similar, which provides experience tables for characteristical value of bearing capacity. The characteristical value is 129.3 kPa obtained by interpolation method.

3.2. Determining Bearing Capacity of Silty Soil by Soil Test Data

3.2.1. Determining Standard Value of Natural Water Content

Using the statistical results, data distribution histogram (see Fig. 2) is performed.

From the above statistical results, natural water content (w) data concentrated mainly in the range of 20%~40%, that was about 87% of total data. If w < 20% or w > 40%, the proportion would be smaller. Based on statistical analysis of the above data, the variation coefficient δ is 0.254, which is greater than the theoretical upper limit value 0.15. If data of w < 20% or w > 40% deviating extensively is eliminated, variation coefficient δ is 0.148, which is less than 0.15. Then, the standard value Φₖ is 24.24, maximum value 31.4, minimum value 20.2, and average value Φₚ = 24.84.

3.2.2. Determining Natural Void Ratio Standard Value

3.2.2.1. Statistics of Natural Void Ratio Data

148 natural water content data obtained from practical engineering got counted according to the distribution range. The results are shown in Table 3.
136 natural void ratio data obtained from practical engineering got counted according to the distribution range. The results are shown in Table 4.

### 3.2.2.2. Calculation and Analysis of Statistical Data

Using the statistical results, data distribution histogram (see Fig. 3) was performed.

![Image](https://via.placeholder.com/150)

**Fig. (3).** Statistical histogram of natural void ratio distribution and number.

From the above statistical results, natural void ratio (e) data concentrated mainly in the range of 0.5–0.9, that is about 90.8% of the total data. If e < 0.5 or e > 0.9, the proportion is smaller. Based on the statistical analysis of above data, the variation coefficient δ is 0.202 without deviating any data, which is greater than the theoretical upper limit value 0.15. If data of e < 0.5 or e > 0.9 deviating extensively is eliminated, variation coefficient δ is 0.117, which is less than 0.15. Then, the standard value Φₙ is 0.688, maximum value 0.889, minimum value 0.505, and average value Φₐ = 0.698.

### 3.2.3. Calculating the Characteristic Value of Bearing Capacity

According to the above standard data of natural water content and natural void ratio, referring to Technical Specification for Building Foundation (DB42/242-2003) and Base Design Criterion of Construction Foundation (GB 50007-2002) [9], the characteristic value of bearing capacity being 198.2 kPa was obtained by interpolation method.

### 3.3. Determining Bearing Capacity of Silty Soil by Double Bridge CPT

#### 3.3.1. Statistics of Double Bridge CPT (Cone Penetration Test) Data

1095 double bridge CPT data obtained from practical engineering were counted according to the distribution range. The results are shown in Table 5.

#### 3.3.2. Calculation and Analysis of Statistical Data

Using the statistical results, data distribution histogram (see Fig. 4) was performed.

From the above statistical results, cone tip resistance (qₖ) data concentrated mainly in the range of 0.75–2.0, about 86.5% of total data. If qₖ < 0.75 or qₖ > 2, the proportion is smaller. Based on the statistical analysis of above data, the variation coefficient δ is 0.617, which is greater than the theoretical upper limit value of 0.3. If data of qₖ < 0.75 or qₖ > 2 deviating extensively is eliminated, variation coefficient δ is 0.267, which is less than 0.3. Then, the standard value Φₙ is 1.367, maximum value 2, minimum value 0.76, average value Φₐ = 1.386 and data number n = 918.

#### 3.3.3. Calculating Characteristic Value of Bearing Capacity

Referring to Technical Standard for Building Foundation (DB42/242-2003) and Base Design Criterion of Construction Foundation (DBJ15-31-2003), the characteristic value of bearing capacity is 134.2 kPa obtained by comprehensive method.

### 4. DETERMINATION OF BEARING CAPACITY OF SILTY SOIL

According to the standard penetration test, soil test and double bridge CPT, comparative analysis result of bearing capacity was shown in Table 6.

### Table 4. Statistical result of natural void ratio data.

<table>
<thead>
<tr>
<th>Void Ratio</th>
<th>e&lt;0.4</th>
<th>0.4≤e&lt;0.5</th>
<th>0.5≤e&lt;0.6</th>
<th>0.6≤e&lt;0.7</th>
<th>0.7≤e&lt;0.8</th>
<th>0.8≤e&lt;0.9</th>
<th>0.9≤e&lt;1.0</th>
<th>e&gt;1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>0</td>
<td>2</td>
<td>19</td>
<td>55</td>
<td>36</td>
<td>13</td>
<td>7</td>
<td>4</td>
</tr>
</tbody>
</table>

### Table 5. Cone tip resistance data collection.

<table>
<thead>
<tr>
<th>Cone Tip Resistance</th>
<th>qₖ&lt;0.5</th>
<th>0.5≤qₖ&lt;0.75</th>
<th>0.75≤qₖ&lt;1</th>
<th>1≤qₖ&lt;1.25</th>
<th>1.25≤qₖ&lt;1.5</th>
<th>1.5≤qₖ&lt;1.75</th>
<th>1.75≤qₖ&lt;2</th>
<th>qₖ&gt;2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>43</td>
<td>47</td>
<td>207</td>
<td>223</td>
<td>190</td>
<td>174</td>
<td>153</td>
<td>58</td>
</tr>
</tbody>
</table>

### Table 6. Comparative analysis result of bearing capacity.

<table>
<thead>
<tr>
<th>Method</th>
<th>Standard Penetration</th>
<th>Soil Test</th>
<th>Double Bridge CPT</th>
</tr>
</thead>
<tbody>
<tr>
<td>characteristic value of bearing capacity (kPa)</td>
<td>129.3</td>
<td>198.2</td>
<td>134.2</td>
</tr>
</tbody>
</table>
For the silty soil sediment in Binzhou area, we should pay more attention to in-situ test methods of standard penetration test and double bridge CPT. Especially, when determining characteristical value of bearing capacity, in-situ test data should be focused on, so that the calculated value can reach more accuracy.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES


