Experimental and Quantitative Study on Micro-structure of Soft Soil in Suzhou

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Abstract. Based on division of the engineering geological strata groups of Eastern Plain area in Suzhou City of China, we identify two soft soil strata among them, which will bring negative impacts on local underground construction. In order to obtain digital micro-structure images of undisturbed soft soil by SEM, free piston thin wall sampler and frozen drying-paste method are used for preparation of the specimens. By utilizing the micro-image processing software of Mifas, we can get the quantitative indicators of the SEM images, such as the index of directionality and eccentricity of particles. It is found that the microscopic structure analysis of two soft soils could appropriately explain their macro-mechanical differences.

1 Introduction

With high water content, strong compressibility, low strength, low permeability, significant rheological behavior, poor engineering properties and low foundation bearing capacity of soft soil, it will bring about bad impact on local underground construction on some occasions. Suzhou is situated on the lower reaches of the Yangtze River and on the shores of Taihu Lake and is a part of the Yangtze River Delta region. In recent years, with rapid growth of urban economy and concentration of population, there are urgent needs to construct urban tunnels and underground infrastructures in Suzhou where quaternary system deposits of soft soil are widely distributed. Therefore, it is important to reveal the local intrinsic reasons regarding its micro-structure variations of soft soil, which could be bound up with its macro engineering properties and environment of sedimentation (Zhou et al., 2011).

Over the last decades, the microscopic research of soft soil mainly refers to following parameter: such as total acreage of particles, statistical perimeter, average pore diameter, shape factor, roundness, anisotropy rate, cementation of clay mineral, inter contacting relationship and so on (Chen, 2011; Li and Hua, 2006). And related testing techniques also appear to develop significantly, such as X-ray diffraction, Scanning Electron Microscope (SEM), X-Ray, CT, digital image measurement, photoelastic experiment, and TDR technology. In this study,

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we used SEM technology to obtain digital micro-structure images of undisturbed specimens of two soft soil strata, and related quantitative indicators of their SEM images, such as the directionality and eccentricity index of particles were accordingly analyzed. Such a work is useful for better understanding the basic engineering properties and sedimentary environment of soft soil strata in Suzhou, as well as providing important experimental data to establish the relationship between soil micro-structure and macro-mechanical characteristics.

2 Experimental Methods

2.1 Sampling Location

According to the basic topography and landform conditions, urban planning area in Suzhou can be divided into two main geomorphic units: the Western Denudation Hilly Area and the Eastern Sedimentary Plain Area. The Eastern Sedimentary Plain Area could also be divided into High Alluvial-lacustrine Plain Area and Low-lying Lacustrine Paludal Plain Area (Cao et al. 2012). Two soft soil strata (3) and (7) are respectively obtained in two boreholes of SZZT16# at Chefang Town and SZZT33# at Zhouzhuang Town (Fig.1). Then free piston thin wall samplers are utilized to get undisturbed soil specimens in the Low-lying Lacustrine Paludal Plain Area. According to the laboratory testing results of soft soil specimens of these two strata, mean value of their physical and mechanical indicators are listed in Table 1. Strata (3) and (7) might function in effect as the first and second soft soil stratum in Suzhou, which are mostly composed of muddy silty clay with high water content, high void ratio, high compressibility, poor permeability, low strength, and strong heterogeneity. These two weak-sensitive strata should be paid more attention to non-homogeneous settlement during the design of shallow foundation structures and underground subway foundations. Due to low shear strength and obvious rheological characteristics of soft soil stratum (3), it is hard for foundation pit to be self-supported during excavation. As for stratum (7), silty clay with fine sand interbed is usually a sediment deposited alternately by silty clay and fine sand, appearing to be a "thousand layers cake".

Table 1 Physical and mechanical indicators of soft soil in Suzhou

<table>
<thead>
<tr>
<th>Stratum</th>
<th>Borehole</th>
<th>Average depth (m)</th>
<th>Void ratio (/)</th>
<th>Water content (%)</th>
<th>Dry density (g/cm³)</th>
<th>Plasticity index (/)</th>
<th>Liquidity index (/)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(3)</td>
<td>SZZT16</td>
<td>5.3–5.8</td>
<td>1.34</td>
<td>49.9</td>
<td>1.16</td>
<td>14</td>
<td>2.22</td>
</tr>
<tr>
<td>(7)</td>
<td>SZZT33</td>
<td>26.9–27.2</td>
<td>1.02</td>
<td>37.1</td>
<td>1.34</td>
<td>10</td>
<td>1.32</td>
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