Study on the lateral displacement of deep water submerged dike structure

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Abstract. With the rapid development of economy, the deep-water wharf, inland waterway, breakwater are increasingly extended to the open sea. Due to the natural environment is getting worse and worse, the construction is becoming more and more difficult. This paper base on a project in He chang zhou waterway section of Long River study on the lateral displacement of deep water submerged dike structure. There are in-site tests to monitor the lateral displacement. The lateral displacement was recorded and a fitting function to predict the long-term settlement was proposed.

1. Introduction

With the rapid development of economy, the deep-water wharf, inland waterway, breakwater are also increasingly extended to the open sea. The project construction will face the situation that the natural environment is getting worse and worse, the foundation conditions are getting worse and worse, and the construction is becoming more and more difficult.

There are two types of theoretical analysis methods for settlement of embankment on Soft Foundation: one is theoretical formula method, the other is numerical analysis method [1]. The theoretical formula method is based on the classical soil mechanics established by Terzaghi[2-7]. This kind of method has many advantages, such as simple, less calculation parameters and easy to obtain, so it is widely used in engineering. The finite element method and other numerical analysis methods can comprehensively consider the deformation characteristics and boundary conditions of soil mass, which is more rigorous in theory, but the calculation parameters of this method are difficult to get, and the calculation workload is large and complex, which can not be widely used. In addition, there are many factors that affect the settlement in the construction process, so the theoretical calculation results can only be used to estimate, and there is still a deviation between the value and the actual observation results. Therefore, in the actual work, it is often necessary to calculate the final settlement and the residual settlement at a certain time in the future through the settlement data (settlement time process line) observed on site.

This paper base on a project in He Chang Zhou waterway section of Long River study on the lateral displacement of deep water submerged dike structure. There are in-site tests to monitor the lateral
displacement. The lateral displacement was recorded and a fitting function to predict the long-term settlement was proposed.

2. **Engineering Profile**

The project is constructing a submerged dike between two river barriers. There are two submerged dikes in He Chang Zhou waterway section, one is located 2100 m downstream of the existing submerged dike, the other one is located 1000 m downstream of the No.1 submerged dike. The elevation of the top of the dike varies greatly. The elevation of the top of the dike at both ends is +4.0 m, +6.0 m, the location of the deep waterway is -18m. The layout of submerged dike is shown in Figure 1.

![Figure 1. The layout of submerged dike](image)

The design wave adopts the method of wave calculation in small wind area, the return period of design wave is 25 years, and the 50 year return period wave is used for verification. According to the calculation, the wave elements of 25-year and 50-year return period in each area of the project are shown in Table 1.

| Wave elements          | 25 return period | 50 return period |
|------------------------|------------------|------------------|
|                        | NW   | E    | NW   | E    |
| Mean wave height H(m)  | 0.56 | 0.48 | 0.63 | 0.54 |
| Average wave period T(s)| 3.3  | 3.1  | 3.5  | 3.3  |
| Wavelength L(m)        | 17.0 | 15.0 | 19.1 | 17.0 |
| Design wave height H_{5%} (m) | 1.34 | 1.15 | 1.49 | 1.28 |
| Design wave height H_{5%} (m) | 1.12 | 0.96 | 1.25 | 1.08 |
| Design wave height H_{5%} (m) | 1.08 | 0.93 | 1.21 | 1.04 |
3. Testing results

According to the measured monitoring data, the lateral displacement time curve of deep soil is shown in Fig. 2.

![Figure 2. The development of settlement](image)

The statistics of lateral displacement and maximum displacement rate of each monitoring point are shown in Table 2. Table 3 shows the displacement rate of each monitoring point in different construction stages. Table 4 shows for the proportion of displacement in total settlement during construction.

| Depth (m) | 0 | 2 | 4 | 6 | 8 | 10 | 12 | 14 |
|-----------|---|---|---|---|---|----|----|----|
| Total lateral displacement (mm) | 7.5 | 6.0 | 5.4 | 5.7 | 0.2 | 0.2 | 0.4 | 0.2 |
| Maximum displacement rate (mm/d) | 0.93 | 1.52 | 0.93 | 0.67 | 0.29 | 0.40 | 0.27 | 0.20 |

Table 2 The statistics of lateral displacement and maximum displacement rate

Table 3 The displacement rate of each monitoring point in different construction stages
During the construction of the main structure of the submerged dike, the deep lateral displacement of the foundation soil is very small, the maximum displacement is 7.5mm, and the maximum displacement rate is 1.52mm/d. The lateral displacement is only the lateral expansion deformation of the foundation soil under the vertical load of the embankment, rather than the sliding caused by the sliding failure. During the construction period, there is no large change of deep lateral displacement caused by uneven loading. Under the action of each level of load, the lateral displacement of foundation soil at different depths has a certain degree. The influence depth changes gradually with the increase of load, and the lateral displacement and velocity of each measuring point increase obviously. With the increase of load, the lateral displacement increases gradually, and the influence depth of the lateral displacement increases.

### 4. Conclusions
This paper base on a project in He Chang Zhou waterway section of Long River study on the lateral displacement of deep water submerged dike structure. There are in-site tests to monitor the lateral displacement. The lateral displacement was recorded and a fitting function to predict the long-term settlement was proposed. The main conclusions are as followed.
The lateral displacement is only the lateral expansion deformation of the foundation soil under the vertical load of the embankment, rather than the sliding caused by the sliding failure. During the construction period, there is no large change of deep lateral displacement caused by uneven loading.

- During the construction of the main structure of the submerged dike, the deep lateral displacement of the foundation soil is very small, the maximum displacement is 7.5mm, and the maximum displacement rate is 1.52mm/d.

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