Study on Settlement Monitoring Technology of Improvement Ground in Transition Section of Immersed Tunnel

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ABSTRACT

For the Hong Kong-Zhuhai-Macao Bridge project, the immersed tunnel is one of the most difficult construction immersed tunnel in the world. The ground of the transition section of immersed tunnel has thick clay with high water content and low bearing capability. The method of compaction sand pile + surcharge preloading was used to improve the soft ground. In order to know the consolidation settlement and residual settlement of the composite foundation in the transition section of the immersed tunnel, and to ensure the safety of the immersed tunnel, the settlement monitoring of the foundation during the surcharge preloading period was carried out. It was hard to do the job because the water depth was more than 20m, and the surcharge preloading zone was offshore more than 200m. The offshore environment had strong wind and wave. It was very difficult to bury the sensor, instrument protection, sealing etc. and the traditional manually measured method had been unable to work at such condition. A new and effective monitoring method was necessary. Through research, a set of monitoring method of using long wire combining with wireless transmission had been developed. The settlement of soil in the process of improvement could be monitored in time. The stable and reliable data were gotten. The degree of consolidation and residual settlement during loading were analyzed, and the reasonable unloading time was determined. And through the analysis of the data, the soft soil foundation in the transition section of the immersed tunnel had been improved well, and the residual settlement was small. It was shown that the monitoring method was successful.

KEY WORDS: Settlement monitoring; Compaction sand pile; Transition section; Immersed tunnel

INTRODUCTION

Hong Kong-Zhuhai-Macao Bridge is a combination of bridges, islands and tunnels. The immersed tunnel connecting the bridge and the island is 5,664m long. Due to different geological conditions, different foundation treatment methods are adopted. According to the tunnel foundation treatment, it is also divided into the foundation section of the tunnel on the island, the foundation of the transition section of the immersed tunnel and the foundation of the middle section outside the island. The foundation of the transition section of the immersed tube is the transition part connecting the foundation on the island and the intermediate foundation outside the island. For those closer to the island, the higher the elevation of the foundation, the thicker the muddy clay stratum. As a result, the treatment quality of the foundation in the transition section of immersed tube directly affects the construction quality of the immersed tube of the whole tunnel. The method of sand compaction pile + surcharge preloading was adopted to reinforce the foundation of the transition section of immersed tunnel. In order to determine consolidation settlement of the foundation in transition section of immersed tunnel and residual settlement, evaluate the effect of foundation reinforcement and determine a reasonable unloading time, the ground surface settlement and layered settlement were monitored during the loading period. Because the immersed tunnel was located in the open sea, and the water depth of the transition section was more than 20m, more than 200m offshore, and the environment was harsh, the traditional settlement observation method had been unable to adapt to the natural conditions of the sea area with strong wind and waves and the construction conditions of underwater heaped load dumping. Therefore, developing a set of monitoring method using long wire combined with wireless transmission and long-distance data acquisition was of great significance to obtain the measured data, analyze them accurately and ensure the safety of constructing immersed tunnels.

FOUNDATION TREATMENT METHOD

Engineering Geology

For the transition section, the elevation of mud line is about -8.0m~10.0m (MSL±0.0). The surface layer is mud or muddy clay stratum and the bottom elevation is about -31.0m. The second layer is an overconsolidated soil layer, which is mainly composed of ③1 clay stratum and ③2 clay mixed with sand stratum.

The mud stratum has high water content and compressibility, while the overconsolidated soil stratum has greater strength and stronger resistance to deformation. For foundation treatment, it is necessary to penetrate the soft soil and enter the bottom of the ③1 clay stratum. See Table 1 for the stratum index to be treated.

Foundation Treatment

For the area of transition section, the method of sand compaction pile + surcharge preloading was adopted for foundation treatment (Jing-yi Mo et al., 2009). The sand compaction pile was arranged in a square layout with a spacing of 1.8m ~ 2.2m, a pile diameter of 1.5m ~ 1.7m, a