

A Successful Case to Mitigate the Slope Instability of Coastal Park in Southern Taiwan during Heavy Waves

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ABSTRACT

The Chi-Chin coastal park, located near Kaohsiung harbor, was built from 1993 to 1997 in southern area of Taiwan. Due to the heavy wave induced settlement inside the park from beach to Art Square during June 1997, the continued soil loss not only endangered the park area, but also resulted in some ground settlement around the front of the Office and Travel Center within the park zone. In order to promptly prevent more ground soil loss, a group of retaining piles was constructed between the beach and Park Office. Until 2003, over almost 6 years, the damage has been not happen in the Chi-Chin coastal park due to the piles installation. From the case, the retaining wall or embedded pile will provide a successful experience for offshore slope subject to wave loadings. Meantime the model derived by minimum energy theory can explain the observed settlement profile in the field. Eventually the full length of pile, even reaches to 14 meter, will provide a good way to mitigate the soil loss of beach while heavy waves attack.

KEY WORDS: Coastal engineering, Slope instability, Liquefaction, Mitigation technique, Retaining wall, Wave induced loads.

INTRODUCTION

The Chi-Chin coastal park, located near Kaohsiung harbor, was built from 1993 to 1997 in southern area of Taiwan. Since the heavy wave loadings induced settlement inside the park from beach to Art Square during June 1997, the continued soil loss not only endangered the park area, but also resulted in some ground settlement around the front of the Office and Travel Center within the park zone. In the past study Hsiao and Huang (2000a) stated that the failure mechanism were discussed and analyzed by using the model fluid-liquefaction. It is found that some areas should be liquefied apparently under given parametric conditions. Furthermore, Hsiao and Huang (2000a) found that liquefaction caused from wave loading leads to reduction of passive soil pressure and causing slope slide instability.

The loss of sands in the zone of Art Square and that in the front of Official Center and behind the pre-cast sheet pile, respectively, were discovered. Based on the direction of loss of sands, the soils at the internal side of PC sheet piles, which includes those located at left side

and front side of Official Center, were continuously taken away owing to the sand scours in the front of sand beach. The possible failure model of soil loss revealed that it might be the wave load results in large excess pore-water pressure in the soil under sea water, which can not dissipates as soon as possible and thus leads to liquefaction; furthermore, the wave induced loads applied onto the soils aside then causes the slope slide instability. These processes continued to occur in the Art Square zone and finally severe failure occurs. After failure, the slope is reduced to be about 0.018-0.02 and a lot of unsaturated sands and sediments have been taken away which causes maximum settlement up to 1.8 m. It seems that the original designed 2m concrete-retaining wall did not work during the typhoon as expected (Hsiao and Huang (2000b)).

Koerner (1994) presented the failure case near sea-wave protection engineering with a rip-rap is induced from inadequate permittivity. Hence soil erosion or soil loss will play an important role for offshore engineering. In addition, if a wall or pile is used, the length is not enough the erosion or soil loss they will give results in serious damage. The study will examine the successful reason of wall or embedded piles again, and study the effect of wall length on the beach liquefaction under heavy waves by means of analytical method of embedded wall developed from Towhata et al. (1999). Towhata et al. used the principle of minimum potential energy at the force equilibrium and the theory of maximum possible displacement to develop a mathematical theory for prediction of the lateral soil displacement. By considering and modifying the boundary of embedded wall, Kogai et al. (2000) indicated that the theory can also predict the settlement and vertical displacement of ground around wall for related engineering. After the proper adjusting boundary condition and numerical calculation, the paper would also try to use the theory to predict and compare with the observed ground settlement profile measured at the site in 1997. In addition, the present study also investigates the effect of pile length on the safety of engineering.

SITE INVESTIGATION AND DESCRIPTION

Figure 1 depicts the overall top view of Chi-Chin Coastal Park, including Art Square, Official Center, Sea-viewing Platform, etc. However, the width of sandy beach varies significantly ranging from