Abstract

Pile-supported T-walls, which are concrete floodwalls that are shaped like an inverted "T" and supported by batter piles, are commonly used by the United States Army Corps of Engineers (USACE) to reduce flood risk for low-lying portions of New Orleans and other areas. The design of a T-wall in southern Louisiana is complex, as the structure needs to resist both 1) large settlements caused by fill placed beneath and beside the T-wall before T-wall construction or by fill placed beside the T-wall after T-wall construction, and 2) large lateral flood loads that are imposed during a hurricane. As a result of these loading conditions, large bending moments can develop in the batter piles and these moments need to be accounted for as part of the T-wall design.

The goal of this research is to develop a more complete understanding of the pile bending moments in T-wall systems, specifically for cross sections where large settlements may occur. As a first step towards this goal, Rensselaer Polytechnic Institute (RPI) performed a series of eight centrifuge tests to investigate and physically model the effects of settlement-induced bending moments on pile-supported T-walls. The centrifuge tests were evaluated and interpreted, and in order to better capture uncertainty, upper and lower bounds were estimated for the interpreted data. The centrifuge results offered some valuable insights on their own, but were ultimately used as the basis for validating and calibrating corresponding numerical models.

The numerical models were developed following a rigorous modeling approach and using rational and reasonable assumptions based on widely-accepted and well-justified procedures. The numerical model results were in good agreement with the centrifuge results without the need for significant calibration or modifications. This good agreement indicates that similar numerical models can be developed to reliably analyze actual T-wall cross sections.

Detailed recommendations were developed for using numerical models to analyze pile-supported T-walls, and an example problem is presented herein that illustrates the application of this approach. These same techniques were then used to perform a parametric study to analyze the combined and separate effects of flood loading for a wide range of different T-wall cross sections. The range was selected in collaboration with the USACE in order to reasonably cover cross sections and conditions that 1) are typically encountered in practice, and 2) were expected to generate both upper and lower bound pile bending moments. In total, 3,648 cross sections were analyzed, and 29,184 sets of analysis results were generated since each cross section was analyzed for eight different loading conditions. Summary results are provided to show the influence of the loading conditions and parameters on T-wall response, including the influence of flood loading, new fill symmetry, pile fixity, number of piles, subsurface profile, pile batter, pile type, levee slope, T-wall elevation, and the presence of existing levee fill. In addition, the key results for all of the analyses are provided in the appendices and in an electronic database.

Based on the parametric study results, a simplified analysis procedure was developed that can be used to calculated maximum pile bending moments for T-walls installed directly on foundation soils due to settlements. In this procedure, the loads from new fill placed during or after T-wall construction are

distributed onto the pile, and the pile response is analyzed using traditional p-y curves and a beam on elastic foundation formulation. This procedure shows good agreement with the numerical model results for a range of conditions. To demonstrate the application of the procedure, the same example problem that is analyzed numerically is reanalyzed using the simplified analysis procedure. Due to the complexity of the problem, it was not possible to modify this procedure or develop a similar procedure for T-walls installed on top of new or existing levees.

Overall, this research demonstrates that numerical models can be used to calculate the bending moments that can develop in pile-supported T-walls due to settlements and flood loading, provides valuable insights into the behavior of T-walls and the influence of various parameters on T-wall response, presents a large database of T-wall analysis results, and recommends a simplified analysis procedure that can be used in some cases to calculate pile bending moments due to settlements.