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SEAL SLAB/PILE INTERFACE BOND

PROBLEM STATEMENT

Bridge superstructures are commonly supported on pile foundations, in which case, the superstructure loads are transferred to a reinforced concrete pile cap that ties the supporting individual piles into a complete structural unit. The piles themselves may be made of reinforced concrete, prestressed concrete or steel.

When the required elevation of the pile cap is below the existing water table (i.e., in the case of excavations or over-water bridges), de-watering of the foundation area must occur to allow for the accurate placement of the reinforcing steel and pouring of the concrete. If global de-watering is not possible because of induced adverse ground settlement or is impractical because of the proximity of a body of water, a cofferdam must be employed.

A cofferdam is a temporary structure usually constructed of thin sheet piles that interconnect to form a water-tight perimeter. Typically, the cofferdam sheet piles are installed first. Then, using a template which locates the pile positions, the piles are driven. Both of the processes are conducted in the saturated or submerged conditions. At this stage of the construction, a cast-in-place concrete (CIP) seal slab is poured at the bottom of the cofferdam with the use of a tremie. This seals the bottom of the cofferdam, preventing the seepage of water, and completes the coffer cell. By design, the top elevation of the seal slab is the base elevation for the structural pile cap. The sheet piles and the seal slab provide the formwork for the reinforced concrete pile cap.

As the function of the seal slab is primarily to provide a dry working surface, its design is relatively unsophisticated. Under current design guidelines it is an unreinforced concrete slab with its depth selected so that its weight largely offsets maximum uplift forces (*for the maximum safe elevation of water outside the cofferdam when completely dewatered*). Allowance for interface bond between the seal slab and the piles is minimal--allowable interface bond is 40 psi for concrete piles and 5 psi for steel piles.

OBJECTIVES

The objective of this study was to evaluate the interface bond between a cast-in-place seal slab and prestressed concrete or steel piles by means of full-scale testing for several simulated cofferdam conditions, including (1) marine conditions, (2) fresh water conditions, and (3) drilling fluid conditions. Normal pile surfaces and the situation of soil-caked piles were investigated.

FINDINGS

Both model and full-scale tests were carried out. In the model tests, a total of 36 one-third scale specimens were tested—twenty-eight prestressed concrete and eight steel. Bonded embedment depth in the seal slab was varied between d to 2d where d was the size of the pile. The results of these tests indicated that shear stress variation was non-uniform, leading to larger computed bond stresses with shallower embedment. Values were least for drilling fluid. Concrete piles had better bond with the seal concrete than steel piles. "Soil-caked" condition was found to be relevant for the drilling fluid situation only. In other cases, it was washed away from the pile surface.

In the full-scale tests, the 32 specimens tested were divided equally between steel and concrete. The prestressed piles were 14 in. square and the steel piles were 14 in. deep wide flange sections. Embedment depth, D, was varied between 0.5d to 2d (i.e., 7 to 28 in., with the larger depth reserved for the drilling fluid condition). Four of the sixteen prestressed piles were cast with embedded gages located at the top, the middle, and the bottom of the interface region. The results of the full-scale tests were similar to those from the one-third scale tests. The most important findings were (1) that loads were transferred over a distance equal to the depth d of the pile, (2) that scale effects were present--the average calculated bond stresses were lower for the full-scale tests than from the corresponding scale model tests, (3) that prestressed piles cracked prior to bond failure, and (4) that the seal slab cracked prior to bond failure.

CONCLUSIONS

Based on the test results it is proposed that the interface bond between piles and the seal slab be restricted to an effective area in contact with the cast in place seal slab. The effective area is calculated using the actual embedment depth (D) or the size of the pile (d), whichever is smaller. The average bond stress over this region is limited to 300 psi for concrete piles and 150 psi for steel piles. These values are reduced by a third (i.e., 100 psi and 50 psi, respectively) in cases where drilling fluid is used. Application of the proposed values to the conditions related to the full-scale tests led to average factors of safety in excess of two for both the prestressed and steel piles. However, tension loads taken by the piles should not lead to cracking (concrete) or exceed the allowable tension load (steel) of the piles. Nor should the seal slab crack.

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