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Numerical analysis of a laterally loaded shaft constructed within an MSE wall

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ABSTRACT

Drilled shafts have been widely used to support lateral loads from superstructures. For typical applications, design methods are available to generate lateral load versus displacement curves and to estimate ultimate lateral capacity and displacement of the drilled shaft under a certain lateral load. However, occasionally drilled shafts have to be constructed within the reinforced zones of MSE walls, for instance drilled shafts supporting sound walls, traffic signs, billboards, and other superstructures. Under these circumstances, existing design methods are not applicable because of: (1) the limited horizontal extent of the soil mass; (2) the resistance from reinforcement; and (3) the influence of MSE wall facing. In this regard, a full-scale field study was conducted to investigate the behavior of shafts within the MSE wall, subjected to lateral loads. The test wall was 43 m long and 6 m high and constructed with layers of uniaxial geogrid and selected backfill. Three-dimensional numerical analyses were performed prior to the construction of this test wall (i.e., Class-A prediction) to guide its design and after the field test using the actual material properties (i.e., Class-C prediction). The selected test shaft for the analyses in this study was located at 1.8 m behind the wall facing. The numerical results from the Class-A and Class-C predictions are compared with the field data. The study showed that the Class-A prediction provided useful information for the design of the test wall and development of field test details. The Class-C prediction improved the overall accuracy of the calculations and could serve as a reference for future study.

1. Introduction

Drilled shafts have been widely constructed to support vertical as well as lateral loads. When shafts are laterally loaded, their ultimate lateral capacities and displacements can be estimated based on load versus displacement curves (i.e., the p–y curves). In this method, a half-space soil medium is modeled as a series of Winkler' springs. The standard procedure for developing p–y curves based on shaft geometry and soil conditions has been incorporated in various software packages, such as LPILE (Ensoft, 2007). However, there are situations under which the standard procedure is not applicable, for example, drilled shafts constructed within the reinforced zones of MSE walls. The following aspects are not considered in the existing design methods: (1) the limited horizontal extent of soil mass; (2) the resistance from reinforcement; and (3) the influence of MSE wall facing.

To investigate the behavior of laterally loaded shafts, full-scale lateral load tests were performed on shafts constructed within a 6 m high, 43 m long MSE wall. Segmental blocks and HDPE uniaxial geogrid sheets were selected as the wall facing and reinforcement materials. Eight test shafts of 0.9 m in diameter were installed at distances of one, two, three, and four diameters (i.e., 0.9, 1.8, 2.7, and 3.6 m) away measured from the back of the wall facing to the center of the shafts. And the MSE wall was divided into different sections to accommodate test shafts. Slip joints were set between sections at MSE wall facing to minimize the influence from adjacent test sections. Details of this test wall can be found in the research report by Pierson et al. (2008).

Prior to the design and construction of this MSE wall, Shaft B located at two diameters (i.e., 1.8 m) behind the wall facing was selected as a prototype for a pre-test numerical modeling (i.e., a Class-A prediction). This numerical analysis was aimed to supply important information for the final wall design and test plan, such as the selection of geogrid reinforcement, the loading equipment with suitable capacities, and the instrumentations, and the test procedure. Based on the data from the Class-A prediction, the design was modified and the final test plan was developed.

During testing, each shaft was loaded laterally towards the wall facing using a displacement control method. These shafts were

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