

Wednesday, 3/15/2017

9:45–11:15 a.m.

Pile, Shaft and Pier Foundations 4

Chairs: Aaron Budge, Minnesota State University, Mankato; Allen Cadden, Schnabel Engineering LLC

Three-Dimensional Soil-Pile Group Interaction in Layered Soil with Disturbed-Zone by Boundary Element Analysis

Jeremy Ashlock and Zhiyan Jiang, Iowa State University

As part of a current research project on dynamic soil-pile interaction, the parallelized Boundary Element Method (BEM) code BEASSI was modified to enable analysis of three-dimensional dynamic behavior of pile groups surrounded by multiple multi-layered soil zones, with rigorous account of radiation and material damping. Dynamic soil-pile interaction was then analyzed in the frequency domain for a single pile and a 2×2 pile group, each surrounded by an inner disturbed-zone and an outer half-space zone. The layered inner zone enables effects of inhomogeneity, pile installation, and strain-dependent modulus and damping to be approximated, while the outer layered half-space zone can account for the far-field wave propagation in a vertically heterogeneous soil medium. The performance of the modified code is validated by comparison to static and dynamic benchmark solutions from the literature.

A general formulation for analyzing the dynamic response of pile groups using impedance functions from the BEM analysis is also presented, with the above-ground pile segments modeled as beam-columns and the pile cap treated as a rigid body. For the present case of the 2×2 pile group, a 24×24 global stiffness matrix is formulated to capture the influence of each pile's six displacement degrees-of-freedom on the other piles due to pile-soil-pile interaction. The form and symmetries of the global stiffness matrix are verified by imposing displacements at the soil surface elevation for each pile cross-section separately, enabling future analyses to be performed more efficiently by specifying displacements at only one of the piles. Results of this study will lay the foundation for developing calibrated computational continuum models by analyzing upcoming full-scale vibration tests of pile groups.

Discussion for Concrete Pier Foundation Design for Transmission Structures

Haijian Shi and Drew Pizzo, Pepco Holdings Inc.

Concrete pier foundations for transmission structures are widely used with high-voltage transmission lines. Current design practice focuses on strength design ensuring the foundation and top structures are safe. However, the performance design criteria for deflection and rotation on top of this kind of pier foundation are not well defined in any major code or guide resulting in utility firms and engineering companies adopting their own differing criteria. This article discusses the development of appropriate performance criteria for foundation design relating to transmission poles. Common pitfalls faced by geotechnical and structural engineers during the design and analysis and ways to avoid them are also discussed. Current common practices and procedures for transmission structure foundation design are discussed together with the importance of adopting appropriate performance criteria to ensure the safety, economic feasibility, and aesthetics of the foundation. Finally, three case studies—tangent pole, light angle pole, and dead end pole—are conducted using the software applications PLS CAISSON, MFAD, and LPILE. The results are compared in terms of shear distribution, moment distribution, and deflection along the length of the pile foundation to establish the ways and extent performance criteria can affect the design.

Case History of a Full Scale Axial Load Test of Sheet Piles

Matthew Sylvain, Miguel Pando, Corey Rice, Matthew Whelan, Vincent Ogunro, and Youngjin Park, University of North Carolina at Charlotte; Thomas Koch, North Carolina Department of Transportation

Short span bridges in the U.S. that are located near rivers and streams typically use sheet piles to defend the abutment against erosion and scour. In such bridges, the abutment axial load demands are usually carried by driven piles installed behind the scour protection sheet piles. An alternative bridge abutment design approach, successfully used for decades in Europe and in some projects in the U.S., involves installing sheet piles for the double function of scour protection and axial load bearing. This design paradigm shift has the potential to significantly reduce construction cost. However, widespread implementation and acceptance of this design approach requires full-scale axial load tests on instrumented sheet piles. This paper presents an axial load test program carried out at a test site in North Carolina that shows that the axial stiffness and load capacity of the sheet pile was comparable to the response recorded in the comparison H-pile when normalized for differences in the tip and surface areas.

Load Testing and Performance of Instrumented ACIP Piles in Texas Clays

Nasser Massoudi, Bechtel Infrastructure; Kenneth R. Bell, Bechtel Infrastructure

A series of instrumented pile load tests was performed on augered cast in-place piles in an area northeast of Austin, Texas. The site soils primarily comprised of clays. The load test program included testing various pile diameters and lengths. Ten compression and tension load tests were performed. Five of the test piles were instrumented with internal strain gages at multiple levels. Load test results provided valuable insight on distribution of loads along the pile shaft and at the toe. This paper summarizes the site subsurface conditions, results of the pile load tests, observed load distribution in instrumented piles, and compares back-calculated skin friction and toe resistance factors from the load tests with those commonly used in pile design.

Variability of Pile-Soil Interaction: A Comparison of Behavior Seen in Instrumented Pile Pairs at Three MnDOT Bridge Sites

Aaron S. Budge, Minnesota State University, Mankato; Derrick D. Dasenbrock, Minnesota Department of Transportation

The Minnesota Department of Transportation has instrumented several driven pile bridge foundations with the intent of gaining an improved understanding of complex pile-soil interaction given various construction layouts, structural and earth fill loading sequences, and geotechnical site conditions. Axial pile loading behavior was examined throughout construction and into bridge service as part of a bridge performance monitoring program. Three similar case studies of instrumented pile pairs at bridge abutments are examined: a comparison of the behavior of a pile within an existing roadway footprint and a pile installed in a widened side-hill fill on a bridge reconstruction project; a comparison of interaction between leading and trailing row piles in a 3-row pile group; and a comparison of pile loads seen on a pile in an integral abutment and a structurally unloaded pile positioned outside the pile cap. These sites have allowed unique observations and interesting conclusions relative to pile-soil interaction.