Monday 3/13/2017

9:45–11:15 a.m.

Pile, Shaft and Pier Foundations 1

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

Parametric Study for Understanding the Behavior of Integral Abutment Bridges

Karrthik Kirupakaran, NTH Consultants Ltd.; Kanthasamy K. Muraleetharan, University of Oklahoma

Integral Abutment Bridges (IABs) are being used widely across U.S. due to the elimination of joints and the superior long-term performance of these bridges. However, the performance of IABs is dependent on the soil-structure interactions that are not well understood. This paper describes an effort to understand the complex soil-structure interactions occurring in IABs through a parametric study conducted to extend the results of a field instrumentation study on an IAB in Oklahoma to other IABs with different design variables. Abutment pile type, size and orientation, bridge length, girder depth, soil type, pre-drilled holes around abutment piles, and bridge skew angle were the variables considered in the study. Validated simulation tools GROUP and TeraDysac were used for the numerical simulations. According to the simulation results, in order to accommodate thermal movement in IABs and to reduce bending moments in abutment piles, a smaller H-pile section should be placed in weak axis bending and in pre-drilled holes with low stiffness material, especially at shallow depths. Abutment piles for IABs should be checked for capacities under combined axial force and bending moments. Longer spans with larger girders will increase the axial load on the abutment piles, and therefore long-span IABs should be designed with caution. For IABs with larger skew angles, abutment piles should be oriented in weak axis bending along the transverse direction. Biaxial bending of abutment piles in skewed IABs increases stresses in the concrete superstructure, thus the structural components for IABs with larger skew angles have to be designed carefully to accommodate the thermally-induced deformations.

Applications of Continuous Wavelet Transform in Crosshole Sonic Logging Tests

Farnyuh Menq, University of Texas at Austin; Shin Tower Wang and William Isenhower, Ensoft Inc.

Crosshole Sonic Logging tests are commonly used to determine the integrity of drilled shafts. However, selections of signal arrival times can be subjective. Different persons may pick different arrival times from the same record. The lack of consistency can be a source of disputes. This paper proposes use of the Integrated Continuous Wavelet Transform (ICWT) method, which applies Continuous Wavelet Transform to interpret direct arrival measurements. The key feature of the method is transferring a nonlinear sinusoidal-like signal to a linear phase angle plot. Peaks in the recorded signal are shown as 0-degree phase. By selecting the time point of 0 degrees with an amplitude above the noise level, the arrival time of the first peak can be uniquely identified. This method removes subjectivity between operators. The ICWT method can also be used for other tests that measure travel time intervals (i.e. pulse echo and seismic CPT tests).

A Robust Method for Lateral Loading Analysis of Large Diameter Piles

Bret Lingwall and Omololu Ogunseye, South Dakota School of Mines and Technology; Byron Foster, Kleinfelder Inc.

One of the principle shortcomings with lateral analysis of large diameter pile foundations is the reliance on beams on elastic foundation. Within numerical modeling, the fundamental nature of the interactions of steel to concrete, steel to soil, and concrete to soil are often difficult to constrain in non-linearity. Modeling with a simplified cracked modulus for the pile does not capture the path from linearity to non-linearity. The progressive occurrence of concrete cracking with yielding rebar and steel casing, with concrete crushing results in pile non-linearly under bending. Furthermore, the interaction of the structural materials and soil beyond Winkler relationships is desirable so that soil can flow around the foundation and assessment of stress changes in the field to affect adjacent facilities. For large displacement problems the ability of the shaft to rotate, bend, shear, twist, and "oval" under complex lateral loads is important. A numerical methodology that addresses these shortcomings was developed. This paper briefly presents the method along with comparison with conventional methods.

Development of Empirical Models to Estimate the Increase in Pile Resistance (Set-Up) with Time

Md. Nafiul Haque and Murad Abu-Farsakh, Louisiana State University

This paper presents the analyses of twelve prestressed concrete (PSC) instrumented test piles that were driven in different locations of Louisiana to develop analytical models to estimate the increase in pile resistance (soil set-up) with time. The twelve test piles were driven mainly in cohesive soils. Detailed soil characterizations including laboratory and in-situ tests were conducted to determine the different soil properties. The test piles were instrumented with vibrating wire strain gauges, piezometers and pressure cells. Several static load tests (SLT) and dynamic load tests (DLT) were conducted on each test pile at different times after end of driving (EOD) to quantify the magnitude and rate of set-up. Measurements of load tests confirmed that pile resistance increases almost linearly with the logarithm of time elapsed after EOD. Case Pile Wave Analysis Program (CAPWAP®) were performed on the restrikes data and were used along with the load distribution plots from the SLTs to evaluate the increase of shaft resistance of individual soil layers along the piles. The logarithmic set-up parameter "A" for unit shaft resistance was calculated for 70 individual clayey soil layers, and the database set of A was correlated with different soil properties. Nonlinear multivariable regression analyses were performed between A and different soil properties, and three different empirical models are proposed to predict the soil set-up parameter "A" as a function of soil properties.

Robust Geotechnical Design of Piled-raft Foundation for Tall Onshore Wind Turbines

Shweta Shrestha, Nadarajah Ravichandran, and Parishad Rahbari, Clemson University

A robust geotechnical design optimization procedure for piled-raft foundation to support a 130 m tall wind turbine on clayey soil is presented in this study. The initial geotechnical design indicated that the differential settlement of the piled-raft system controls the final design. A parametric study was conducted by varying the wind speed and undrained cohesion to establish a relationship between the design variables (number and length of pile and radius of raft) and random variables (wind speed and undrained cohesion). Finally, a robust design optimization was conducted considering the material cost and the robustness as the objectives. The standard deviation of the response which is the differential settlement of the foundation system was considered as the measure of robustness of the design. The optimization yielded a set of acceptable designs and presented as a Pareto front which can be used to select the best design using the knee point concept.

Drivability and Performance of Steel H-Piles in Schist Saprolite

Lei Gu and Ara G. Mouradian, Gannett Fleming Inc.; Sarah E. McInnes, Pennsylvania Department of Transportation

Although driven steel H-piles are often an economical alternate for bridge foundations, prediction of pile drivability and length in very dense saprolite remains a great challenge pertaining to design and construction practices. A study to evaluate the performance of steel H-piles driven into thick saprolite layers was conducted for several bridge projects in Southeastern Pennsylvania. These saprolite layers of the Wissahickon Schist Formation are completely weathered but retain the fabric and structure of the parent bedrock. A database of numerous test piles from selected projects was established to provide a quantitative understanding of pile geotechnical resistances, pile lengths and a qualitative prediction of the driving conditions. All piles were driven to absolute refusal which is a function of the hammer type, efficiency, and driving procedure. High strain dynamic tests were performed on all piles at the end of initial driving. The results of restrike testing on selected piles were used to evaluate set-up effects on piles in these intermediate geomaterials. Geotechnical resistances from Case Pile Wave Analysis Program (CAPWAP) were compared against static analysis values to quantify the pile performance. In addition, statistical attributes of the pile database were summarized for pile embedment into saprolite, hammer efficiency, and maximum driving stresses, etc. The paper presents the results of the pile drivability study, identifies the influence of saprolite thickness on pile geotechnical resistances and lengths, and provides recommendations for future projects with similar design challenges.