Florida Department of Transportation Research

Resistance Factors for 100% Dynamic Testing, with and without Static Load Tests
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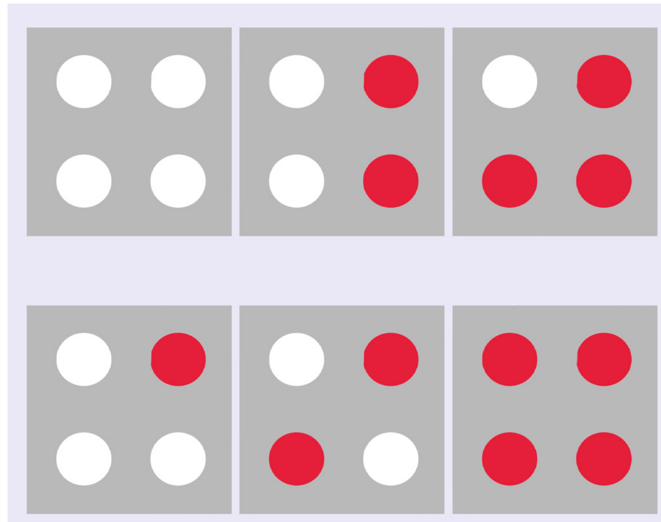
The Federal Highway Administration (FHWA) and most state departments of transportation have adopted the Load and Resistance Factor (LRFD) approach to design. Critical to the design of piles in this approach is the development of a resistance factor, Φ. LRFD allows a number of approaches to calculate this resistance factor, depending on the most significant aspect of the construction. However, resistance factors cannot be adequately predicted a priori, and data from field testing at the site are required to guide the calculations.

The accuracy of resistance factors developed in this way depends in part on the layout of the piles and how many and whichthe number and location of the piles are monitored, as well as accuracy of the testing methods. Small changes in the resistance factor have a large impact on the overall design of the bridge and significant implications for project economies in terms of pile design, construction equipment, and construction schedules. In this project, researchers explored a more explicit approach to incorporating pile layout, monitoring patterns, and test method uncertainties into the calculation of pile resistance factors.

To focus their efforts, researchers first investigated the relationship between the probability of failure (POF) of a bridge to the number and arrangement of piles and piers. The POF is closely related to the reliability factor and, in turn, the safety factor, a fundamental parameter of the design. The researchers determined that the number of fully redundant piles in a pier is far more important than the number of nonredundant piers, and therefore, the development of LRFD Φ should begin with the pier and include the number of piles and the distribution of monitored and unmonitored piles within the group.

Next, the researchers tackled the question of determining the spatial uncertainty of pile configurations and error in the field methods, including Standard Penetration Test (SPT), Embedded Data Collection (EDC), and Pile Driving Analyzer (PDA). Spatial uncertainty was analyzed for single pile resistance from SPT data, and then extended through statistical methods (i.e., kriging) to group layouts. The extended approach was then applied to EDC and PDA data.



For a square arrangement of four piles, there are several possible monitoring patterns. Each one has its own statistical interpretation in deriving an appropriate resistance factor.

Equations and charts were developed to quantify group uncertainty CVR and LRFD Φ for typical group layouts and patterns of monitoring. The latter approach was considered to be inflexible, and the spatial uncertainty was replaced with hammer monitoring in conjunction with high strain rate monitoring. Using the uncertainty of monitoring method (CVεm) and a measured uncertainty of blow count regression (CVεh) versus high strain rate monitoring, an LRFD Φ equation was developed for pile groups considering the numbers of monitored and unmonitored piles. The developed expression was evaluated at two sites and gave reasonable predictions compared to current practice.

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