Florida Department of Transportation Research

Development of Variable LRFD ϕ Factors for Deep Foundation Design Due to Site Variability

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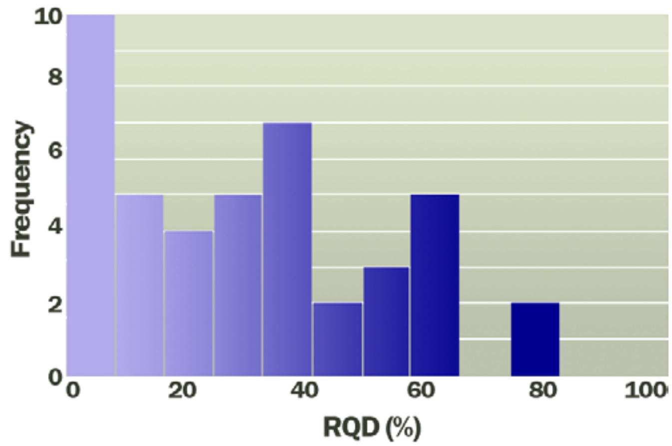
Both the Florida Department of Transportation (FDOT) and the Federal Highway Administration (FHWA) specify use of fixed resistance factors (ϕ) for Load and Resistance Factored Design (LRFD) of deep foundations, depending on design approach and redundancy of the foundation. A specified ϕ for a design requires a certain level of reliability, a function of uncertainties associated with material properties, construction methods, and selected design approach. Subsurface spatial variability is a significant uncertainty; for instance, Florida's coastal terrain presents stiff challenges to quantifying variability of soil/rock properties.

Previously, University of Florida researchers (FDOT project BDK545-76) developed geostatistical tools to evaluate spatial uncertainty, which can be added to design method error to obtain the total uncertainty of drilled shaft side resistance, from which resistance factors can be computed. This project included shaft tip resistance as well as other deep foundation types (driven piles) and design methods, such as CPT.

To assist design engineers with geostatistical site analysis, the researchers developed a graphical user interface (GUI) independent of pile/shaft analysis software (e.g., FB-DEEP). The GUI separates the site's in situ/lab data by layers, from which summary statistics and spatial correlation length (vertical and horizontal) are found. Next, the GUI generates thousands of boring logs for any planned pile/shaft foundation from either conditional (nearest boring) or unconditional whole site data. Then, the GUI assesses the mean and standard deviation (spatial uncertainty) of pile/shaft capacity by analyzing the generated boring logs. Finally, the GUI sums spatial uncertainty to site-specific design method error (site load test results) or legacy data (default) to obtain total uncertainty, and then computes a set of LRFD ϕ for the design.

Researchers used the combined GUI/FB-DEEP to analyze seven FDOT bridge sites. The amount



Rock quality density (RQD) for a boring at the 17th Street Bridge in Ft. Lauderdale shows how variable rock/soil characteristics can be for a Florida site.

and type of in situ and laboratory strength data for the sites varied widely and included results from soil penetration testing (SPT) and laboratory unconfined compression and split tension testing. For each site, both unconditional and conditional analyses were performed.

The study revealed the importance of sufficient in situ, laboratory, and field load test data to obtain a specified resistance factor for a pile/shaft of a given length. For instance, the highest resistance factors (0.7) came from sites with the most vertical and horizontal data, followed by sites with well-defined vertical information (point data and correlation lengths); the lowest factors (0.3) came from the sites with limited data. The report includes recommendations on improving computed resistance factors on a site-by-site basis.

In summary, this project provided analytical software, GUI and FBDEEP, to evaluate pile/shaft axial capacities and LRFD resistance, ϕ, values on any site based on collected in situ (SPT, CPT), laboratory, and construction (load testing) data. The software also aids in allocating resources, such as borings and load testing, that balance economy and providing foundations with specified levels of reliability and service life.

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For more information, visit http://www.dot.state.fl.us/research-center