Florida Department of Transportation Research

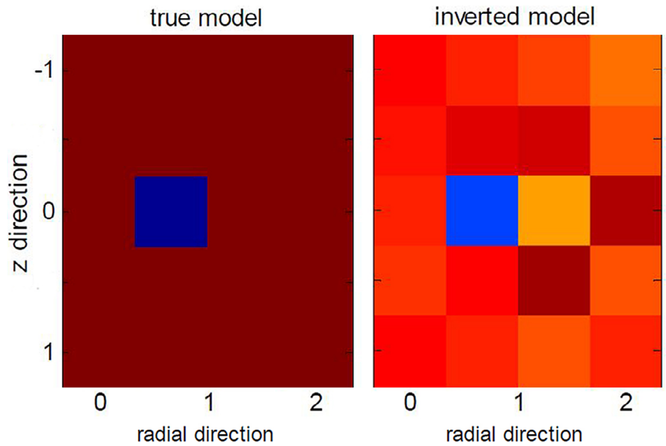
Continuation of Down-Hole Geophysical Testing for Rock Sockets
BDK75-977-51

The rock socket is critical to a drilled shaft foundation because it lies within a rock stratum and accounts for much of the capacity of the foundational unit. Consistency of the rock's structure and composition must be identifed because it can be highly variable.This problem is acute in Florida, where sand, clay, limestone, and voids can be layered in highly variable geological profiles. Unanticipated ground structure below a site can cause significant construction delays and disputes. Therefore, more accurate site characterization is crucial for ensuring reliable and economic substructure design.

Traditional invasive exploration methods, such as standard penetration or cone penetration tests, sample small volumes of material, resulting in generalizations that may insufficiently assess spatial variations. Standard seismic methods, such as seismic refraction and surface waves, are used for subsurface investigation but are limited in characterizing complex geological profiles. These and all surface-based methods have limited resolving ability at depths needed to assess rock quality for rock-socketed drilled shafts.

University of Florida researchers have devised a new borehole-based method of characterizing subterranean profiles, overcoming other methods' shortcomings and providing higher resolution. In this new method, images of the shear wave velocity profile are created along and around the borehole to provide credible socket material analyses and detect nearby anomalies. Physically, the method relies on sensors placed vertically along the borehole wall to capture elastic seismic waves. Mathematically, the method relies on full-waveform inversion (FWI) to develop a series of two-dimensional images from seismic data.

FWI has been used with surface-based data, but the complexity of wave propagation in boreholes required researchers to develop new, mathematically viable equations. Exact solutions for this problem were possible only for the simplest situations, so researchers used a finite-element approach to create numerical solutions.



This graphic shows the detection of an anomaly (blue square) in one of the simulation scenarios used to test the authors' method.

The researchers used FWI in a modeling system that coupled a forward and an inverse model. The forward model used seismic data to predict subterranean structure, then the inverse model reversed the process to match the original seismic data. By adjusting model parameters, the coupled model produced the best interpretation and image of the seismic data.

This complex procedure was tested in five simulations. A homogeneous medium was used in the first four scenarios: an isolated anomaly near the borehole; an isolated anomaly further from the borehole; two isolated anomalies in the same plane; and two isolated anomalies in opposite planes. The fifth scenario involved an isolated anomaly in a horizontally layered medium.

Using their new technique, researchers detected the number, distance, and azimuth of isolated anomalies near a borehole. This method promises a powerful new tool for geotechnical site investigations resulting in deep foundation designs, with expedited construction, significant savings, and more reliable structures.

Project Manager: David Horhota, FDOT Materials Office
Principal Investigator: Dennis R. Hiltunen, University of Florida

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