Florida Department of Transportation Research

Detection of Sinkholes or Anomalies Using Full Seismic Wave Fields: Phase II

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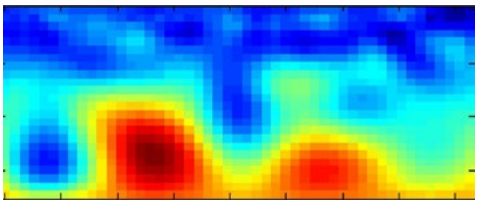
Current Situation

Florida geology with its non-uniform rock and soil layers, variable deposits of poor soils (clay, organics, etc.), and weathered (and possibly voided) limestone is a major concern for design engineers, contractors, and maintenance personnel. However, determining the makeup and integrity of the underlying soil layering can be challenging. A better and more thorough means of assessing and understanding a larger area of the subsurface at construction sites would help to determine the exact needs of a project or to efficiently maintain existing infrastructure.

Research Objectives

Previously, the researchers developed a nondestructive surface test that uses seismic waves to yield useful information about subsurface conditions, showing its effectiveness at identifying and locating voids and anomalies (FDOT project BDK75-977-66). In this project, they further developed the method's software and tested a field-deployable version.



The highly variable top of a limestone layer appears red and orange in this "snapshot" of an underground section, 40 ft wide and 18 ft deep.

Project Activities

The seismic technique relies on full waveform inversion (FWI), a mathematical procedure that uses all the data within the waveforms from seismic testing to develop higher resolution seismic wave velocity profiles of underground conditions. To better adapt the process for field use, the researchers examined ways of speeding up the FWI, which can be time consuming because of the large amount of data collected and used in the analysis. Using appropriate mathematical constraints and computing innovations, they were able to obtain seismic wave velocity profiles of the subsurface condition in 20 to 30 minutes. When more detailed analyses are needed, the FWI can be run at varying frequencies in the office after field testing is complete.

With the accelerated FWI, the research team went on to develop an interface to guide operators in using the software. The interface facilitates and simplifies the required steps in processing and analyzing seismic test data and provides for labeling, storing, and reporting data for later use.

The researchers tested the software using computer simulations of typical Florida geological conditions, using the FWI to detect the voids at various depths and locations. This suggested that the depth of detection was dependent largely on the size of the void; the maximum embedded depth at which voids were detected with confidence was about three void diameters (e.g., a ten-foot diameter void could be detected up to 30 feet deep. Voids not directly under the test line were still identified if the test line was near the void edge; however, the void became distorted and was not identified if the test line was at least one diameter from the void.

For field testing, the team chose five Florida sites based on their history of sinkhole activity, their record of other types of ground testing, and the results of their previous project. Multiple seismic test lines at each site showed that the FWI software successfully characterized highly variable soil/rock layers and embedded low-velocity anomalies. Seismic testing using the FWI software agreed well with other field tests (standard penetration test and cone penetration test).

Project Benefits

An effective site investigation method for characterizing subsurface conditions over a relatively large area has extensive and valuable applications in Florida. This allows for better knowledge of the subsurface conditions thereby improving the design of pavements and structures, reducing construction conflicts due to unknown site conditions, and providing for improved maintenance of existing infrastructure ensuring long term integrity and lower maintenance and replacement costs.

For more information, please see dot.state.fl.us/research-center