Florida Department of Transportation Research

Detection of Sinkholes or Anomalies Using Full Seismic Wave Fields

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Sinkholes are a common feature of Florida's geology. The limestone that runs throughout the state is acted upon by the constant flow of water, both above and below ground, that changes with wet and dry seasons. Subsurface voids can form, causing overlying strata to break and collapse, forming surface depressions that may develop over periods ranging from hours to months.

As Florida becomes more populous and developed, there are more interactions between the built environment and Florida's sinkhole geology. Insurance claims for sinkhole damage almost tripled from 2006 to 2010, from over 2,300 to more than 6,600. Claims for these events amount to hundreds of millions of dollars a year. The ability to detect sinkholes and regions of potential subsidence before construction could significantly reduce these events and the associated costs.

Methods of sinkhole detection often have limitations. For example, one method that looks for small changes in gravitation that might signal a subsurface void requires the void to be fairly close to the surface, and even then, if it is filled with water, the void might not be detected. In this project, researchers from the University of Florida and Clarkson University (Potsdam, NY) demonstrated an analysis ofseismic testing results to detect and categorize subsurface anomalies.

The method uses traditional seismic test procedures. Any impact on the ground generates waves; sensors (geophones) detect these waves and produce a record called a seismogram. Waves shown in the seismogram can overlap in complex ways, and waves of interest might not be the most prominent, so sensitive analyses are needed to draw out relevant information. To do so, the researchers in this project used a technique called full-waveform inversion (FWI), a mathematical procedure which takes advantage of the computer power that is now available to utilize the entire seismic waveform and produce more detailed information about subsurface conditions.

A sinkhole has destroyed one home and threatens another.

The researchers tested their FWI analysis on computer models of embedded voids, both air-filled and water-filled. From these idealized scenarios, they developed the same type of data that would be taken in the field and fed that information into their FWI analysis. In a second round of simulations, field data with known voids and sinkholes was analyzed. This process showed that it was possible to detect voids and to discern other types of heterogeneity, such as different soil types or whether the void was water filled.

Based on the success of FWI in simulations, the researchers proceeded to full-scale field tests. FWI was applied at increasingly complex sites: an embedded culvert with known size and depth; a deposit with a known subsurface anomaly; a site with open chimneys (sinkholes); and a site with a suspected but unidentified sinkhole. These investigations were generally successful, and they also informed the researchers about potential improvements to the system.

More accurate detection and identification of subsurface anomalies before construction will allow more informed design decisions, with the potential to save builders, occupants, and insurers many millions of dollars.

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