Florida Department of Transportation Research

Sinkhole Detection with 3-D Full Elastic Seismic Waveform Tomography

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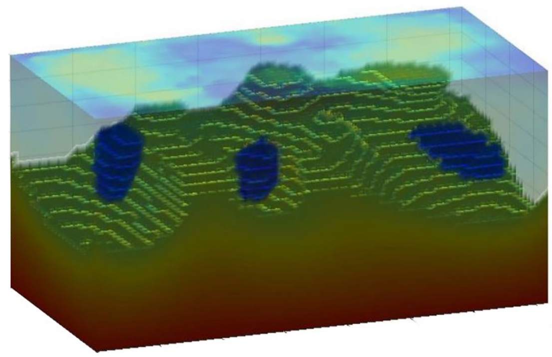
Current Situation

Geologically, Florida is a broad shelf made of limestone, formed by sea life over the millions of years that Florida was underwater. Voids can develop in the limestone, causing the overlying stone and soil to collapse, forming a collapse-type of sinkhole. Some sinkholes are large, but most sinkholes are small and appear as depressions or funnels into the ground. Voids and sinkholes are common in Florida and present serious challenges for construction. Finding sinkholes can stall construction while testing is conducted, which may require additional steps to create proper foundations or project relocation. Detecting voids or uncollapsed sinkholes early in the design process can prevent very costly solutions.


The FWI method gives this image of the structure under a field. The top of the box is the ground level. The hilly structure is limestone under the soil, and the blue areas are anomalies: two voids and an area of soft soil.

Research Objectives

University of Florida researchers developed and tested a method – 3-D full waveform inversion (FWI) – for detecting sinkholes using seismic waves and state-of-the-art analysis.

Project Activities

Seismic waves are pressure waves that travel through the ground. They can be generated by striking the ground and detected with sufficiently sensitive equipment. An array of detectors can provide information about underground structures, including soil-rock layering, voids, and sinkholes. The challenge is to correctly interpret the detector information. The researchers' FWI method is based on complex computations that produce a 3-D view of underground features.

To verify the method of seismic data collection and FWI data processing, the researchers constructed two virtual terrains typical of Florida geology. One terrain included a large subterranean void, and the other a small void. The researchers were able to use these terrains to collect virtual data and then apply the FWI method, providing an opportunity to find the optimum source-receiver spacing and the maximum void detection depth.

The methods refined in the virtual setting were applied at two real Florida sites. First, the researchers collected data at the site with a known underground feature: a stormwater pipe. They were able to detect the pipe and its direction, length, and depth. Second, they applied the technique at the site with unknown features: a retention pond. The results suggested variable soil-rock layering and shallow embedded anomalies, which was confirmed by standard penetration tests (SPTs).

The researchers continued field testing with a source that gave waves with greater energy at lower frequencies, allowing detection of objects at greater depths. This was used with FWI alone and with FWI and SPT testing at a North Florida retention pond site and a South Florida bridge construction site with good results. The researchers reported that this method can be completed in two days: one for data collection and one for FWI analysis on a standard desktop computer. The researchers recommended a 3.2 GHz processor speed and 300 GB RAM.

Project Benefits

This project presents a powerful new tool that can be combined with traditional methods for accurately mapping out the underground structure of construction sites.

For more information, please see www.fdot.gov/research/.