Florida Department of Transportation Research

In-service Assessment of Road Sinkholes with 2D Ambient Noise Tomography

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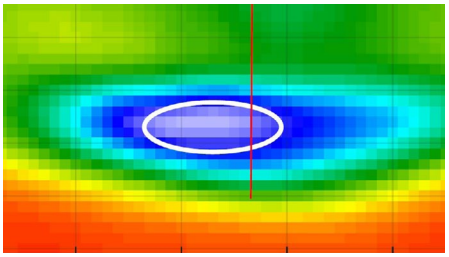
Current Situation

Florida's limestone foundation is subject to formation of subsurface voids caused by the passage of water or acidic groundwater conditions. When these voids collapse, sinkholes form and, depending on the size of the void, they can develop quickly. Regardless of size, if a sinkhole forms under a roadway, it can significantly damage the road and endanger road users. Several methods are available to detect underground voids, but they often have limitations. For example, ground-penetrating radar cannot reliably detect voids deeper than about 20 feet, and seismic methods, which can detect voids at 60 ft depth, often require road closures.

Research Objectives

University of Florida researchers developed a novel method that uses traffic noise as a source for 2D ambient noise tomography (2D ANT) to detect subsurface voids up to a depth of 100 feet.



In this subsurface scan created using the methods developed in this project, the white ellipse marks an underground void.

Project Activities

Tomography is a method of assembling signals from many angles to create a three-dimensional image. This is the basis of computer-aided tomography, or the CT scan, that is used to image the interior of the human body. Tomography requires a source and a detector. In a CT scan, the source is X-rays and the detector is a special camera. For subsurface tomography, the source is seismic waves, often caused by an artificial shock, and the patterns (vibrations) these seismic waves produce are captured by detectors laid out over a wide area, which allows subsurface structures to be reconstructed.

The researchers observed that traffic noise might be useful for subsurface tomography because it is (1) rich in low frequency vibrations that are important for detecting voids at depth and (2) rich in higher frequency vibrations that improve resolution of underground images. The researchers tested this idea using computer models and simulated traffic noise against models of small shallow voids and large deep voids, using 24 or 48 simulated receivers.

Once developed in computer simulations, the methods were tested at four field locations where voids had been found during construction or by maintenance. One sinkhole had previously been repaired and needed additional work. At each site, 24, 36, or 48 detectors spaced at five feet along a line were used to collect traffic noise signals. Data collected for up to 20 minutes gave subsurface profiles that generally agreed with other methods.

This method has several advantages. First, no direct shock is needed, thus minimizing the risk of inducing collapse. This also reduces setup time and cost. Second, the land-streamer geophones used as detectors can be set up in a few minutes on asphalt pavement, and data are acquired with minimal traffic interruption. Third, traffic noises from passing vehicles with various weights and speeds are sufficient to create the wide frequency range needed for subsurface imaging at good resolution and accuracy at much greater depths than comparable geophysical surface methods.

Project Benefits

This new method for detecting underground voids offers better detection with less equipment setup, less interference with traffic, and producing results to much greater depths than other surface test methods.

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