

Request for Research Funding for FY 2019-2020

Requesting Office	Geotechnical	Priority	4 of 4
Proposed Title	In-service Assessment of Road Sinkholes with 2D Ambient Noise Tomography		
Justification	Sinkholes within a roadway typically first appear as surface deflections in the pavement. These surface deflections could also be caused by many other factors, such as leaking drainage structures or underlying poor foundation soils. If the cause is a sinkhole and left untreated, an opening and collapse of the roadway can result posing a significant risk to the safety of the traveling public. A better site investigation method is needed to evaluate the subsurface conditions to identify the cause of these surface deflections. If a sinkhole is the cause, successful early detection of the pre-collapse sinkhole is crucial to minimize this risk. Borings and soundings have the limitation of testing a small volume of soil and can easily miss smaller sinkhole features. Seismic methods are often used for sinkhole detection. For example, 2D/3D full waveform inversion (FWI) methods (developed through FDOT funded projects) using active wave-fields can be used to identify a buried void to a depth of three void diameters. However, they require multiple source impacts to generate the active wave-fields, and the data acquisition time is significant. This leads to long lane closures while testing. This proposed work aims to minimize the length of time for lane closures during data acquisition. The goal is to reduce the overall test time to obtain results in a timely manner to provide the engineer with an assessment of the site conditions to be able to make quick decisions regarding road closures and remediation procedures needed.		
Impact	The proposed research is to develop an ambient noise tomography (ANT) method, which can extract 2D P-wave and S-wave velocities to depths of 100 feet using only traffic noises as a source. There are several advantages of the proposed ambient noise approach. First, no active source is needed (i.e. hammer blows) which reduces test time significantly. Second, wireless geophones can be deployed quickly in a few minutes, and data are acquired with short traffic closures. Third, traffic noises are rich in a wide range of frequencies, which are important to resolve deep structures to depths of 100 feet but also allow for higher resolution characterization of relatively small-scale cavities and voids nearer to the surface.		
Affected Offices	Geotechnical, Design, Maintenance, Materials. Updates by the researcher will be presented in annual Geotechnical Research in Progress (GRIP) meetings to district geotechnical staff and consultants.		
Existing Work	FDOT Research Projects, BDK-75-977-66 and BDK-31-977-66, Detection of Sinkholes or Anomalies Using Full Seismic Wave Fields (Phases I and II), established a new 2D full waveform inversion (FWI) method and software to improve the practice of sinkhole detection. The current project BDV-31-977-82 Sinkhole Deflection with 3D Full Elastic Seismic Waveform Tomography is using this method for a 3D grid pattern to capture the data for a single mobilization of the receivers but still needing multiple hammer blows at various locations throughout the grid.		
Keywords Used In Existing Work Search (Cannot leave blank)	ambient noise tomography, full waveform inversion, sinkhole seismic		
Related Contracts (Give contract numbers)	The following FDOT research contracts and associated papers: BDK-75-977-66, Detection of Sinkholes or Anomalies Using Full Seismic Wave Fields (Phase I) BDK-31-977-66, Detection of Sinkholes or Anomalies Using Full Seismic Wave Fields (Phase II) BDV-31-977-82 Sinkhole Deflection with 3D Full Elastic Seismic Waveform Tomography		
Funding Request	\$200,000	Anticipated Duration	24 months
Project Manager	David Horhota	Contracting Method	Direct contract with University of Florida (Dr. Khiem Tran)
Urgency	2	This project would deliver a geophysical tool that will provide the Department with the capabilities to conduct a quick in-service scan of sinkholes under or near roadways. The results will be obtained in near real-time to allow engineers to assess the site conditions	

		very quickly to assist them in responding to the immediate problem, including whether to close the road and what is the best means of remediation.
Implementability	2	The State Materials Office currently performs geophysical and non-destructive testing for sinkhole investigations, and this unique analysis methodology will improve the Department's capabilities of identifying voids and delineating their limits, specifically for voids directly under a roadway. The State Materials Office already has the existing equipment to perform seismic testing, and this project's results will expand the application of the use of this equipment. This analysis methodology is not available through any specialty consultant and would be unique to in-house use.

Project Benefits (Succinct, complete explanation)

This project would deliver a geophysical tool that will provide the Department with the capabilities to conduct a quick in-service scan of sinkholes under or near roadways. The unique analysis methodology to be developed will work in conjunction with equipment already owned by the Department. This analysis will use ambient traffic noise as the source, making the test much quicker and providing much deeper results than current seismic test and analysis methods. It is intended as an on-road test to assess a 'big picture' view of the conditions under or near the roadway with minimal time delay to the traveling public (i.e. short duration lane closures). The results of this test would provide subsurface conditions to identify the cause of localized roadway depressions (sinkhole, leaking drainage structure, compressible soils, etc.) to assist the engineer with more cost effective and efficient remediation procedures.

Project Benefits (Select all that apply and explain)	Quantifiable Benefits (units, dollars, etc...if applicable)	Methodology or Data Sources Used to Determine Quantifiable Benefits. If not applicable, please give justification of project benefits
<input type="radio"/> Materials Enhancement	Better knowledge of subsurface conditions	Any geophysical test has the advantage over conventional borings or soundings to assess the soil properties over a larger area. Soil properties can change over a relatively small area and these changes can be missed by conventional testing. Therefore, more accurate geotechnical properties which are applicable over a larger area can be obtained and used by the geotechnical engineer in assessing the cause of localized roadway depressions. This method also offers to opportunity to obtain survey depths down to 100 feet which is nearly twice as deep as comparable seismic test methods.
<input type="radio"/> Materials Savings		
<input type="radio"/> Time Savings	Quicker test time compared to comparable geophysical tests	No active source (hammer blows) is needed since this method will use existing traffic ambient noise. Wireless receivers will be used to quicken the time to set up for a test. These factors will allow data to be obtained with minimal lane closures. Because of this, test results will be available quickly to assess the subsurface conditions and allow for decisions to be made on-site regarding road closures and remediation procedures.
<input type="radio"/> Lives Saved/Injuries Prevented		
<input type="radio"/> Other (Explain)		

*Comments should explain and support urgency, financial benefit, and implementability scores