

Request for Research Funding for FY 2021-2022

Requesting Office	Geotechnical	Priority	1 of 5
Proposed Title	Use of 3D Seismic Waveform Tomography with SPT-Source for Geotechnical Site Characterization		
Justification	<p>The project BDV-31-977-82 Sinkhole Deflection with 3D Full Elastic Seismic Waveform Tomography successfully used the full waveform inversion (FWI) method and software method with conventional geophysical seismic test equipment for a 3D grid pattern to capture the data for a single mobilization of the receivers with multiple hammer blows at various locations throughout the grid. As part of this study, a unique case study arose at a south Florida project site where a large void was discovered during construction which prevented a full array of sensors to be laid out due to physical constraints of adjacent roadways. The researchers were able to use the conventional Standard Penetration Test (SPT) as a source at varying test depths along with a smaller array of surface sensors to produce results to depths in the range of 80' to 150'. The increased energy of the SPT source closer to the void also produced high resolution information to identify the void very accurately, which was confirmed by borings and sonic caliper measurements. Being the first use of this technique, the current project is needed to optimize this type of analysis, automate the field data collection, and reduce the overall time to obtain final results to allow its use by geotechnical practitioners.</p>		
Impact	<p>Any geophysical test has the advantage over conventional borings or soundings to assess the soil properties over a larger test 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 and remediation of subsurface anomalies, voids, or problematic soils. Many current methods are restricted in providing high resolution of underground features to relatively shallow depths in the range of 30' to 50'. This method allows at greater depths, with higher resolution, and a smaller test area needed at the ground surface than traditional geophysical and seismic test methods. In addition, it utilizes a source than is typically used in conventional geotechnical site investigations, the Standard Penetration Test (SPT); therefore, the goal of this project is to combine the benefits of both test methods (the known and conventional SPT used on nearly all site investigations and the high resolution geophysical seismic test to obtain more information about the subsurface conditions over a larger volume of the test area) into one test program.</p>		
Affected Offices	<p>Geotechnical, Design, Materials. Updates by the researcher will be presented in annual Geotechnical Research in Progress (GRIP) meetings to district geotechnical staff and consultants.</p>		
Existing Work	<p>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.</p>		
Keywords Used In Existing Work Search (Cannot leave blank)	<p>seismic tomography, full waveform inversion, full seismic wave fields</p>		
Related Contracts (Give contract numbers)	<p>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 BDV31 TWO 977-122 In-service Assessment of Road Sinkholes with 2D Ambient Noise Tomography</p>		
Funding Request	\$300,000	Anticipated Duration	30 months
Project Manager	David Horhota	Contracting Method	Direct contract with University of Florida (Dr. Khiem Tran)

Urgency	5	This project would deliver a geophysical tool that will provide the Department with the capabilities to conducting a high resolution, deep survey to assess subsurface site conditions over a large volume of the proposed test site. It can do this with a small area at the ground surface which is advantageous for urban settings. It can also be performed while typical borings with Standard Penetration Tests (SPTs) are performed to act as source and ground-truthing of the seismic test results. Results can be used for varying purposes, including sinkholes investigations, identifying top of rock/bearing layer for deep foundations, assessing varying site conditions, or delineating the presence of non-select soils. The results will provide a large 3D picture of the subsurface conditions to increase information to the geotechnical engineer, thereby increasing confidence in decisions made regarding problematic site conditions.
Implementability	5	The State Materials Office currently performs geophysical seismic testing, and this unique analysis methodology will improve the Department's capabilities of identifying voids and varying site conditions at great depths with a high degree of resolution. 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. The goal of this project is to combine conventional SPTs with this high resolution geophysical seismic test into one single phase of the subsurface investigation program, optimizing the overall test time in the field.

Project Benefits (Succinct, complete explanation)

This project would deliver a geophysical tool that will provide the Department with the capabilities to conducting a high resolution, deep survey to assess subsurface site conditions over a large volume of the proposed test site. It can do this with a small area at the ground surface which is advantageous for urban settings. It can also be done while typical borings with Standard Penetration Tests (SPTs) are performed to act as source and ground-truthing of the seismic test results. As a result, the goal of this project is to combine conventional SPTs with this high resolution geophysical seismic test into one single phase of the subsurface investigation program, optimizing the overall test time in the field. Results can be used for varying purposes, including sinkholes investigations, identifying top of rock/bearing layer for deep foundations, assessing varying site conditions, or delineating the presence of non-select soils. The results will provide a large 3D picture of the subsurface conditions to increase information to the geotechnical engineer, thereby increasing confidence in decisions made regarding site conditions. The unique analysis methodology to be developed will work in conjunction with equipment already owned by the Department.

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
<ul style="list-style-type: none"> ○ 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 and remediation of subsurface anomalies, voids, or problematic soils. This method also offers to opportunity to obtain survey depths down to 150 feet which is nearly twice as deep as comparable seismic test methods performed entirely at the ground surface.
<ul style="list-style-type: none"> ○ Materials Savings 		
<ul style="list-style-type: none"> ○ Time Savings 	Quicker overall field-testing times	Since this new test technique uses Standard Penetration Tests (SPTs) as an active source for the seismic testing, both tests will be performed at the same time to optimize the overall test program. Since it is highly recommended that some ground-truthing borings are performed along with geophysical testing to enhance the analysis of the results, this new technique will combine both at the same time resulting in time savings. In addition, combining both test methods can allow the advantages of geophysical testing to be realized on more conventional site investigations and not only for sinkhole investigations.

○ Lives Saved/Injuries Prevented		
○ Other (Explain)		

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