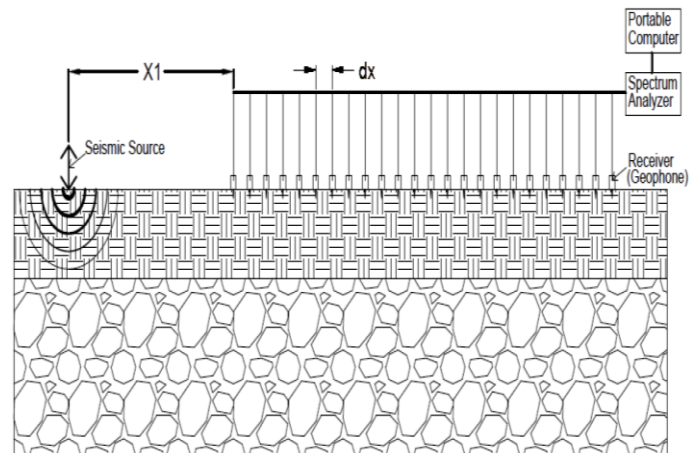


## Development of the MASW Method for Pavement Evaluation

**OVERVIEW:** According to the American Society of Civil Engineers, Arkansas roads cost residents \$634 million a year in extra vehicle repairs and operating costs, moreover 39 percent of Arkansas roads are in poor or mediocre condition. To reduce both of these numbers, the Arkansas State Highway and Transportation Department and other DOTs/highway departments must develop or implement techniques to plan and budget for roadway repairs and future replacement. Effective methods will yield dense and robust measurements while being conducted in a rapid, non-destructive manner that minimizes traffic disturbance. Currently, there are some nondestructive tests (NDTs) in practice that are rapid and produce robust results, but only the spectral analysis of surface waves (SASW) and the multichannel analysis of surface waves (MASW) directly (i.e., not through a correlation) produce physical properties of a material such as Poisson's ratio or shear modulus. SASW was originally developed to test pavements, but it has several limitations in that it cannot detect higher modes and the data processing method requires substantial time and skill. MASW was developed as a continuation of SASW and improves on the deficiencies of SASW. There is extensive research on MASW testing for soils but little research has concentrated on pavements. The purpose of this research is to test four parameters (source type, source offset, receiver spacing, and number of receivers) used in MASW field testing to determine the optimum testing procedure. Additional research was conducted to determine the ability of MASW to measure a degradation in shear wave velocity due to an increase in material damage.

**RESEARCH SUMMARY:** The MASW testing procedure involves a seismic source that generates surface waves and accelerometers that measure the propagation of that wave. It is a multichannel method (i.e. 24 receivers) that records data in the space-time domain. The general procedure is shown in Figure 1.



**Figure 1 Basic MASW Testing Procedure**

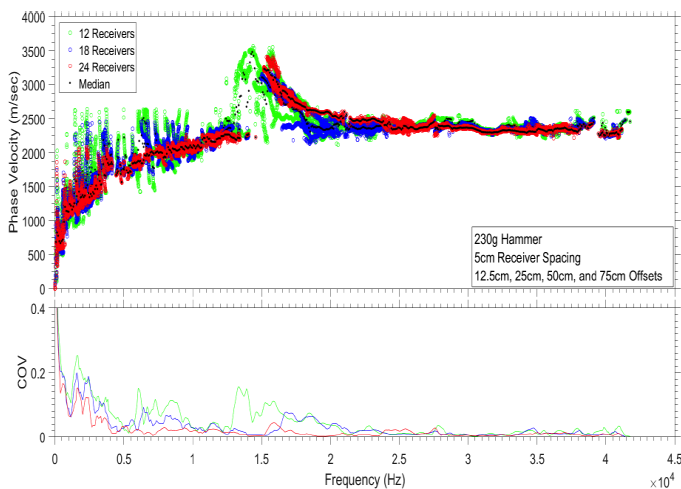
The MASW optimum field testing parameter phase of this research focused on three materials common in transportation: asphalt, concrete, and soil. There were two asphalt sites ("CTTP Asphalt" and "ENRC Asphalt"), two concrete sites ("ENRC East Concrete" and "ENRC West Concrete"), and one soil site ("CTTP Soil"). All of the sites are located at the University of Arkansas Engineering Research Center located in Fayetteville, Arkansas. In addition, research was also done on the effect of lateral variability on Rayleigh wave propagation. This was accomplished by constructing a box with dimensions of 1.22 m wide by 2.44 m long by 2.44 m deep with a cast-in-place (CIP) concrete wall along one of the 2.44 m long walls.

The final portion of the research focused on examining the relationship between a degradation in shear wave velocity and material damage. First, concrete prisms were constructed in accordance with ASTM C1293. There were three groups of prisms constructed, one being a control and the other two containing varying amounts of Jobe sand, which is known for causing alkali-silica reaction (ASR). Second, the ability of MASW to detect a degradation in shear wave velocity as material damage increases was determined. This was accomplished by testing three sites located on a barrier wall along Interstate 49 south of Fayetteville, Arkansas. These three sites



(known herein as “C-1”, “C-2”, and “C-3”) have varying levels of reactivity and their strains are currently being monitored.

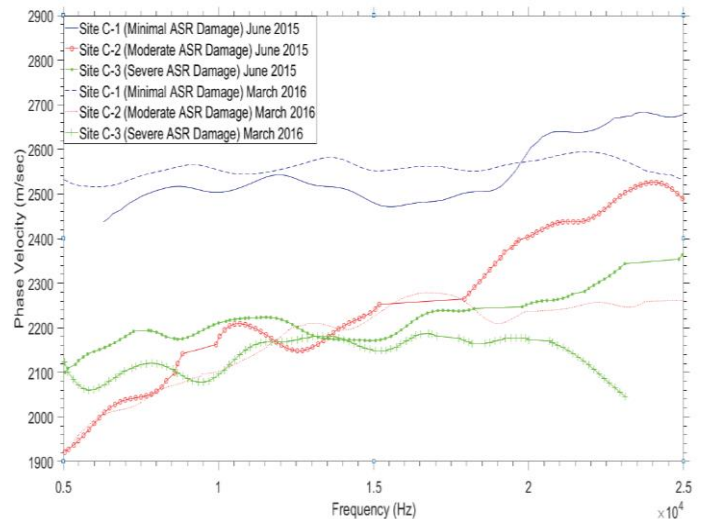
**RESULTS:** It was determined that for the data collected on asphalt, the optimum procedure included a 230g metal-tipped hammer, 2.5 cm receiver spacing, a minimum of 24 receivers, and source offsets of 12.5 cm, 25 cm, and 50 cm. For concrete, the optimum procedure included a 230g metal-tipped hammer, 5 cm receiver spacing, a minimum of 18 receivers, and source offsets of 12.5 cm, 25 cm, 50 cm, and 75 cm (Figure 2).



**Figure 2 Results from a Concrete Section**

For soil, the optimum procedure included a 230g metal-tipped hammer, 5 cm receiver spacing, a minimum of 12 receivers, and source offsets of 12.5 cm, 25 cm, and 50 cm.

Additionally, it was determined from a limited data set of six tests, that MASW has the ability to detect a decrease in shear wave velocity as damage increases up to a strain level of at least 0.09% (Figure 3). However, MASW testing done on concrete with expansions of 0.09% and 0.29% showed only a 2% difference in shear wave velocity between the two large strain sections. Given the data collected, it cannot be determined if MASW can be used to differentiate between concrete sections with strains larger than 0.09% (i.e., sections with heavy damage).



**Figure 3 Results from Barrier Wall Sections**

## About the Researchers

Dr. Clinton M. Wood from the University of Arkansas – Department of Civil Engineering served as Principal Investigator. Masters student Benjamin Davis also contributed to the work.

The Southern Plains Transportation Center is a consortium of eight universities in U.S. Department of Transportation Region VI: the University of Oklahoma, Oklahoma State University, Langston University, University of Arkansas, University of New Mexico, Louisiana Tech University, University of Texas at El Paso and Texas Tech University.



The SPTC provides a unique opportunity through multi-institutional initiatives to develop comprehensive, cost-effective, and implementable solutions to critical infrastructure issues facing the transportation systems of the region and the nation, and to prepare transportation professionals for leadership roles through *Research, Leadership, Collaboration, Education, Outreach, Tech Transfer* and *Workforce Development* activities.