COMPARING SHEAR-WAVE VELOCITY PROFILES INVERTED FROM MULTI-CHANNEL SURFACE WAVE WITH BOREHOLE MEASUREMENTS

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Recent field tests illustrate the accuracy and consistency of estimating near-surface shear (S) wave velocities calculated using multichannel analysis of surface waves (MASW) (Park et al., 1999; Xia et al., 1999; Miller et al., 1999). To evaluate the technique in a variety of near-surface conditions and through a wide range of velocities, MASW-derived S-wave velocity profiles (S-wave velocity vs. depth) were compared to direct borehole measurements at four North American sites. A detailed study of the effects of the total number of recording channels, sampling interval, source offset, and receiver spacing on the inverted S-wave velocity was conducted at a test site in Lawrence, Kansas. Optimization of the method provided generally applicable rules of thumb that have resulted in differences between inverted S-wave velocities between the MASW method and borehole measurements to be as low as 18 percent, with potential improvement as low as 9 percent (Figure 1).

A surface wave survey was performed in Wyoming to determine shear-wave velocities in near-surface materials (upper 7 m) as a direct result of mode converted shear wave refraction data. In the 0 to 6 m range, the average difference between S-wave velocities estimated from the MASW method and those measured from suspension logging is less than 15 percent (Figure 2).

Validation of the MASW technique requires comparison between several borehole-derived velocity profiles as well as blind testing. MASW-derived S-wave velocity profiles were statistically compared to S-wave velocity profiles measured in seven boreholes in the unconsolidated sediments of the Fraser River Delta, near Vancouver, B.C., Canada. An overall difference of approximately 15 percent was observed between the direct borehole measurements and inverted S-wave velocities from the seven well locations. A blind test of the stand-alone accuracy of MASW was conducted at an eighth well. For this blind test, S-wave velocity measurements made in and interpreted from the borehole were not available during MASW data processing. Differences between S-wave velocities using MASW and those measured in the blind test borehole was 9 percent (Figure 3).

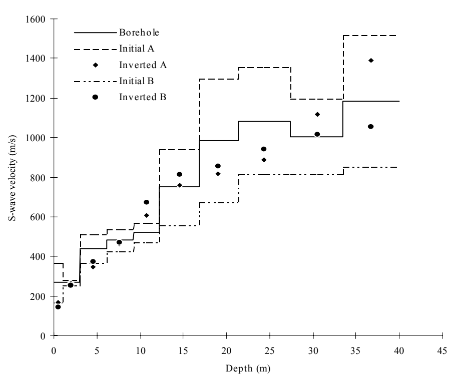

Figure 1. Borehole measurements and inversion results of surface wave with two initial models (Lawrence, Kansas).

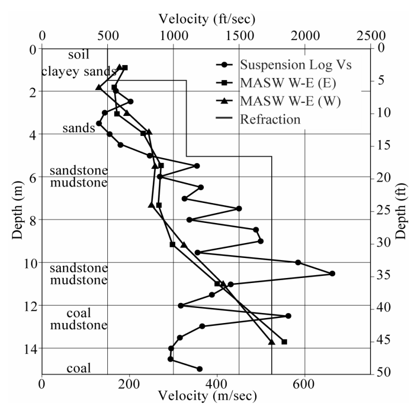

Figure 2. Vs from Suspension log, refraction, and MASW methods (a testing site in Wyoming).

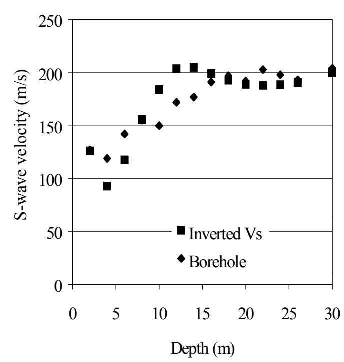

Figure 3. Borehole measurements and inversion results of surface wave (Vancouver, British Columbia, Canada).

Inverted S-wave velocities calculated using the MASW technique at a landfill site in Johnson County, Kansas, are within 15 percent of borehole measurements, which were treated as ground truth. Mode conversions along sloping subsurface refracting horizons can result in misidentification of shear wave velocity.

No systematic difference between these results were observed in data from any of these test sites. The MASW method provided reliable S-wave velocity profiles within the upper 30 meters below the ground surface.

References:

Miller, R.D., Xia, J., Park, C.B., and Ivanov, J., (1999), Multichannel analysis of surface waves to map bedrock, *The Leading Edge*, 18(12), 1392-1396.

Park, C.B., Miller, R.D., and Xia, J., (1999), Multi-channel analysis of surface waves, *Geophysics*, 64(3), 800-808.

Xia, J., Miller, R.D., and Park, C.B., (1999), Estimation of near-surface shear-wave velocity by inversion of Rayleigh waves, *Geophysics*, 64(3), 691-700.