Multichannel Analysis of Surface Waves (MASW): Application to Roadway Design

Student: Alex Osuchowski
Faculty Advisor: Russell A. Green (rugreen@vt.edu)
Sponsor: Virginia Tech
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Project Background

Multichannel Analysis of Surface Waves (MASW) is a common geophysical testing method with many useful applications in geotechnical engineering. MASW testing can be used to determine the shear-wave velocity profile at a site (e.g., Figure 1). With this information, the geotechnical engineer can determine small strain soil stiffness parameters, such as shear modulus and Young’s modulus which can be used in foundation and roadway design, as input to earthquake site response analyses, etc. MASW testing is non-invasive.

During MASW testing, a perturbation is created at the ground surface (e.g., sledgehammer or weight drop impact) and the resulting propagation of Rayleigh waves is measured (see Figure 2). Rayleigh waves are a type of surface wave often referred to as “ground roll.” In a layered medium, such as a subsurface composed of soil layers increasing in stiffness with depth, Rayleigh waves are dispersive. This means that waves of varying frequency (and corresponding wavelength) will propagate at different velocities. In a subsurface increasing in stiffness with depth, a high frequency (short wavelength) Rayleigh wave will travel at a slower velocity compared to a low frequency (long wavelength) Rayleigh wave.

![Figure 1. Example shear-wave velocity profile.](image)

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Clay/Silt: $V_s = 100 - 1000$ ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sand: $V_s = 300 - 1700$ ft/s</td>
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<tr>
<td></td>
<td>Till: $V_s = 1000 - 2500$ ft/s</td>
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<tr>
<td></td>
<td>Granite: $V_s = 5600 - 11500$ ft/s</td>
</tr>
</tbody>
</table>

![Figure 2. Dispersion of Rayleigh waves.](image)
Project Objectives

The principal objective of this research is to determine if MASW testing can be used as an efficient, non-invasive, and inexpensive method for assessing subgrade stiffness of a paved (or soon to be paved) roadway. In order to achieve this, we intend to complete the following:

1. Become proficient in MASW data acquisition and processing.
2. Determine if a correlation exists among MASW, Dynamic Cone Penetrometer (DCP), and California Bearing Ratio (CBR) test metrics.

Research Progress and Plans for the Future

Research tasks are listed below (completed tasks are italicized):

1. Review existing literature on Spectral Analysis of Surface Waves (SASW) and MASW test methods.
2. Perform field surveys at multiple sites of varying geologic/subsurface conditions. Perform testing on paved road surfaces.
3. Perform DCP (ASTM D6951/D6951M – 09) and CBR (ASTM D4429 – 09a) testing at the same sites where MASW testing is performed. Use hand auger to retrieve soil samples to classify soil type.
4. Construct three “test strips” approximately 100-feet-long by 15-feet-wide and perform the above mentioned tests. Test strips will be constructed by excavating to a depth of approximately 6 feet and backfilling in a controlled manner. Soil properties such as in situ density will be known.