Multichannel analysis of surface waves: evaluating the effects of acquisition parameters in distinguishing shallow subsurface structure

Jaime Lovell
Email: mark.lackie@mq.ed.au

This article reports on Jaime Lovell's Honours project which was sponsored by the ASEG Research Foundation and supervised by Mark Lackie at Macquarie University.

Project summary

S-wave velocity is an important parameter in many engineering geophysics investigations such as site characterisation, and ripability determinations. Multichannel Analysis of Surface Waves (MASW) is an alternate seismic method to refraction for gaining shear wave velocity profiles of the shallow subsurface.

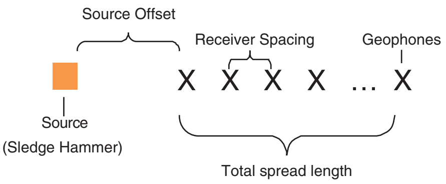

Fig. 1. *Diagram depicting the field parameters investigated.*

MASW utilizes the dispersive nature of Rayleigh waves to gain Shear wave velocity information in either one dimensional or two dimensional formats in a time efficient and cost effective manner.

This project aims to assess the effects of acquisition parameters in MASW on the dispersion curve analysis and the accuracy of the resultant S-wave velocity models across three different soil profiles around Sydney: weathered shale on sandstone at Macquarie University; quartz sand near the Middle Macdonald River, St Albans; and clay derived from a dolerite intrusion at Prospect Hill.

MASW relies on accurate dispersion curve analysis in order to determine the Shear wave velocity (Vs) profile, and thus the field parameters are chosen to enhance the surface wave signal responsible for the dispersion curve. There is a significant range between the upper and lower limits of the recommended field parameter guidelines put forward by researchers. A series of controlled field tests were conducted at each site whereby the field parameters source offset, receiver spacing (and receiver spread length), and the frequency of geophones were varied (see Figure 1). The results of the tests were compared to establish the optimum field parameters for each site based on the dispersion curve analysis and resultant S-wave profiles, and to

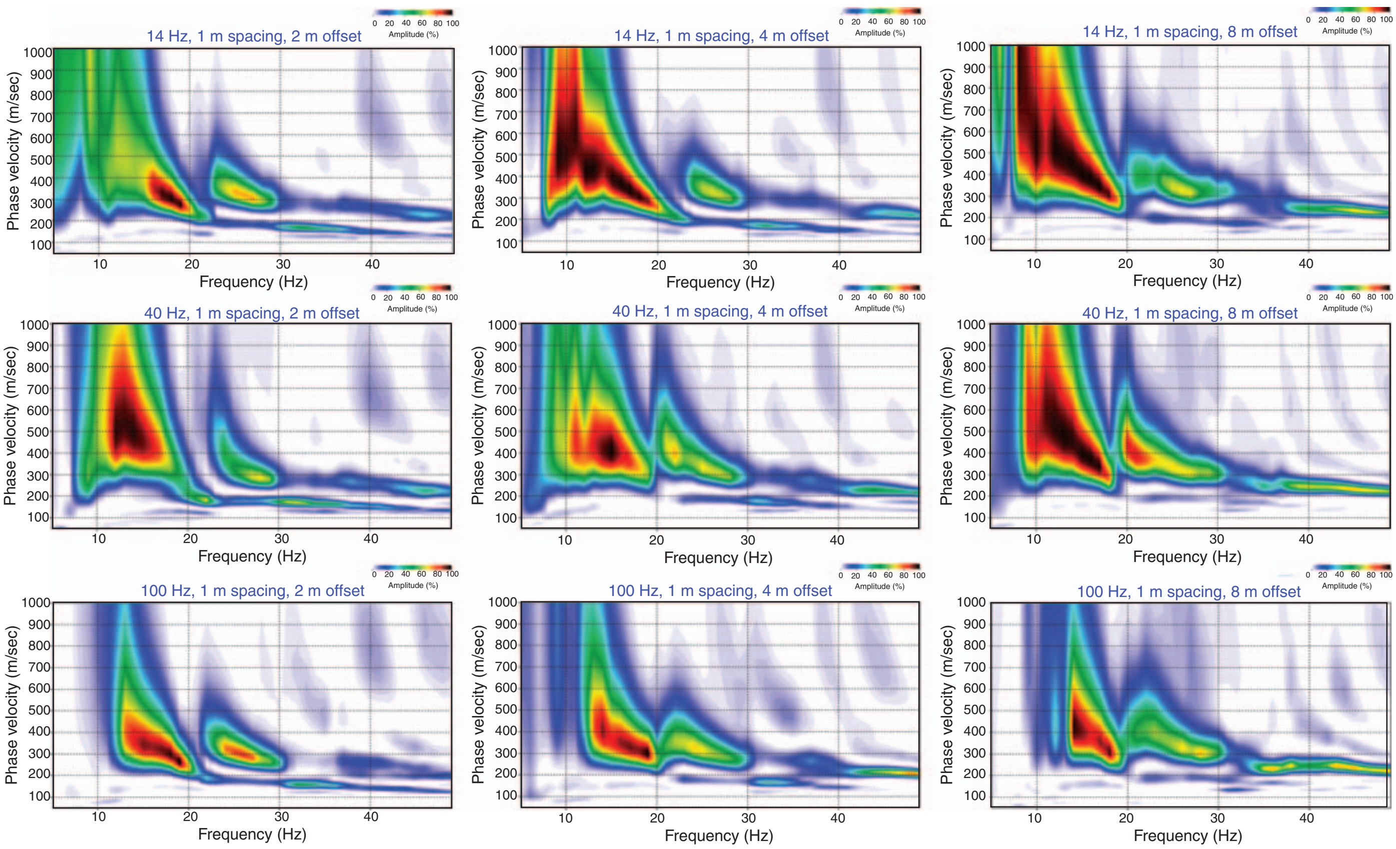

Fig. 2. *Example of the dispersion curve comparisons at Prospect Hill. The first row shows results for 14 Hz phones, while the second is for 40 Hz and the third for 100 Hz. The first column shows data with a 1 m geophone spacing and a 2 m shot offset. The second column shows a 1 m spacing and a 4 m offset, while the third column shows a 1 m spacing with an 8 m offset.*

ascertain the usefulness of MASW to distinguish near surface structure in the different soil types.

The MASW method is most suited to use on soils and was found to be beneficial for use in sites where gradual velocity changes occur and therefore is generally well suited to Australian environments due to the highly weathered and variable nature of many locations. It was effective at Macquarie and Prospect Hill in providing accurate results, at which gradual velocity changes exist. Shorter offsets gave better results than the far ones, as the longer offsets tended to increase the depths determined to layer boundaries. For the shorter offsets the different frequency geophones (14, 40 and 100 Hz) were comparable to the standard 4.5 Hz geophones. The higher frequency phones also allowed for easier identification of higher modes. The receiver spacing had the greatest impact on the resultant dispersion curves and V-s profiles, where the longest receiver spacing gave a significantly deeper depth estimate to layer boundaries. See Figure 2 for examples of dispersion curves for different parameters for tests done at Prospect Hill.

The MASW method was an unsatisfactory method for delineating subsurface structure of a sharp acoustic contrast at the uniform sand site of St Albans. Although ground roll was identifiable on the record, the results showed the inability of the method to model the high contrast between the unconsolidated sand and consolidated sand and therefore only penetrated a few metres allowing only the top uniform layer of sand to be profiled.

The results of this study have shown that altering the receiver spacing and total spread length has a large impact on the resultant dispersion curves and inverted profiles. The results also demonstrated the advantages of using a shorter source offset. The geophone frequency was not found to have as significant effect as the receiver spacing and spread length, potentially making the method more available to those that have access to standard seismic recording equipment without needing to purchase low frequency receivers. MASW was found to be a quick and easy method to determine S-wave velocities of subsurface layers where gradual velocity boundaries occur.

Project outcomes

The principal outcomes of the project were:

1. MASW is a fast and effective method for accurately deducing S-wave velocity profiles where gradual velocity changes occur.
2. The field parameter receiver spacing had the largest impact on the analysis of results, while the different geophone frequencies were comparable at shorter offsets and even allowed for higher mode identification more clearly.