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Detection of Underground Obstacles by the SASW Test

The ability to detect the position and material characteristics of underground obstacles is important in civil infrastructure maintenance, repair and rehabilitation. In many urban areas where congested utility lines and underground cavities hamper reconstruction and repair, an accurate profile of subsurface conditions is most helpful to design and field engineers. Presently in New York Metropolitan area, as with many other large urban areas, pavement system and utility maintenance managers rely mostly on plans and profiles obtained from original design information. In many cases, changes are not reflected in the available information, resulting in serious delays and monetary loss. Therefore, there is a clear need for a tool for rapid and relatively accurate determination of underground conditions. A number of geophysical techniques are being tested for this purpose including the proposed Spectral-Analysis-of-Surface-Waves (SASW) technique.

The Spectral-Analysis-of-Surface-Waves (SASW) is a nondestructive in situ seismic testing method used in evaluation of shear wave velocity profiles of layered systems. An extensive numerical analysis focusing on the influence of the various underground obstacles on dispersion curve resulted in a conclusion that the method shows a potential for identification of underground obstacles in terms of their horizontal and vertical position, the width and the density of the obstacle. This research focused on verifying the potential of the method for detection of underground obstacles in laboratory and field conditions. In order to accomplish that objective, the influence of obstacles of different size, shape, rigidity and depth of embedment on the shape of the dispersion curve has been analyzed. The research results confirmed that obstacles cause change in the dispersion curve pattern. In particular, rigid obstacles cause increase in the phase velocity, while flexible obstacles cause decrease. Flexible objects affect dispersion curve pattern more significantly than the rigid ones. If a loose, flexible, material surrounds a rigid obstacle, the response (surface wave dispersion) is governed by properties of the flexible material. For the receiver spacing in the range of the obstacle size and depth of embedment, the effect on the dispersion curve becomes more pronounced as the obstacle gets thicker and/or shallower. In general, for a large receiver spacing only a change in the phase velocity is observed, while for a short receiver spacing both the phase velocity change and strong fluctuations in the dispersion curve is observed. Horizontal distance to the obstacle can be determined from the receiver location that corresponds to the most significant changes in the dispersion curve. Depth to the obstacle can be determined from the wavelength at which fluctuations in the dispersion curve vanish. The research confirmed that the SASW method could be successfully used for identification of underground obstacles in terms of their horizontal and vertical position and the density of the obstacle. For the purpose of laboratory and field application of the method, a computer application that serves automatic acquisition of surface waves data, analysis in the frequency domain, and graphical presentation of the results has been developed.