geotechnical and geophysics – bridging the gap

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The Geotechnical Engineering industry often faces the dilemma of acquiring detailed subsurface borehole information at inaccessible locations. This may be due to existing underground utilities, overhead transmission lines, or formidable terrain. This dilemma frequently results in drilling boreholes at less than optimum locations to obtain desired engineering parameters for a project. Confidence in the acquired data applying to a sometimes-far-removed site is severely decreased.

Enter the science of geophysics. Commonly used geophysical equipment for characterizing the shallow subsurface is reasonably portable, allowing measurements to be made at sites inaccessible to a geotechnical drill rig. Two frequently used measurement methods are seismic refraction and electrical resistivity. Seismic refraction can provide 2-D layered solutions as well as velocity tomograms. These same seismic data can produce MASW results in either 1-D or 2-D format. Electrical resistivity data are analyzed to produce 2-D resistivity tomograms. Implementation of the two methods allows interpretation of the subsurface, taking advantage of both methods because the geology may not produce diagnostic data sets.

Extending this approach, we have compiled a database containing seismic and resistivity results and common geotechnical parameters obtained from boreholes. The database contains geophysical and geotechnical data from the same selected locations in various geologic settings. Our vision is to use a machine learning approach to learn or map the relationship of the geophysical values to the geotechnical parameters, thus addressing the dilemma of not being able to acquire geotechnical data at challenging sites.

To date, initial results are encouraging. Using an MLP (multi-layer perceptron) neural network and geotechnical data from six bridge sites in central Montana, USA, we were able to achieve a correlation coefficient of 0.919 by using network inputs of: seismic p-wave velocity, electrical resistivity, seismic s-wave velocity, and IP (induced polarization) to predict UCS (unconfined compressive strength), static modulus, moist unit weight, and moisture content of clay soil and shale bedrock. We are continuing our efforts to expand the database encompassing a variety of geologic settings and locations and exploring alternative machine-learning approaches.