Seismic tomography utilises multiple raypaths to achieve 3-D modelling of crosshole seismic data. Historically, crosshole seismic was limited to individual shots in a horizontal plane. Improved software and equipment now allows for multiple raypaths to be recorded for each shot location. The raypaths provide a wealth of information across the entire volume between boreholes. The ability to perform 3-D analysis is an important advantage in counteracting the problem of non-uniqueness with crosshole data.

Data production is maintained by utilising a string of geophones in the receiver borehole creating 24 raypaths for each shot. The information is recorded in the field using the seismograph. Geophone separation and the interval between source shots are dependent upon the survey objectives and site conditions. Borehole separation of up to 50 metres can be achieved where ground conditions and noise are at acceptable levels.

Seismic tomography is processed using the GeoTomCG 3-D package which provides graphical displays of velocities, raypath densities, and other parameters for data analysis and modelling. Plots for quality control include travel time versus distance, residual versus raypath angle, velocity versus raypath angle, and others. When needed, anisotropy can be performed on required points within the grid to improve the modeling of anomalies.

Source and receiver coordinates are calculated to provide an accurate 3-D grid. The tomographic analysis calculates velocities at points across the grid using the simultaneous iterative reconstruction technique. This modification of the initial velocity values consists of repeated cycles of three steps: forward computation of model travel times, calculation of residuals, and application of velocity corrections.

A typical presentation of the data is by 3-D numerical results or 2-D slices of the velocity profile across areas of interest. According to the geology and number of boreholes, multiple slices will be taken to clearly present the 3-D analysis in full. Interpretation features include depth of bedrock, layers within the surficial soils, voids and shear zones.

The figure illustrates crosshole seismic tomography data combined with the geological log of the borehole. Higher velocities are seen within the dense sandstone regions whereas slower velocities are present in the conglomerates and weaker sandstone layers.

Applications

- Earthen dam stability assessments
- Mapping geological structures and voids
- Rock mass assessments for tunnelling
- Mineral exploration