SeisOpt® ReMi™ software: Refraction Microtremor Field Tutorial
30-meter Shear Velocity With Using Standard P-wave Geophones

ReMi™ uses standard refraction equipment to determine one-dimensional S-wave velocities for seismic effect studies before or after construction. You simply record noise from your site. No seismic source is required. User's can collect good data at the noisiest urban sites using a two person crew-in two hours or less. Builders can now economically and efficiently comply with recommended UBC regulations for determining NEHERP soil classification of their building sites.

1. Equipment Needed: All you need is 24-channel digital refraction gear with 8-12 Hz single phones.

a. Most digital refraction seismographs built since 1990 should be adequate, digitizing 24-bit fixed-point or 21-bit floating-point samples. The recorder must have enough memory to hold 24-channel records with a length of 4 seconds or more. The Geometrics StrataView R and Seistronix RAS-24 are examples. (The Geometrics SmartSeis™ can only record a maximum 1-second record length.)
b. The geophone array should be 200 meters long, and must be more than 100 meters. The refraction cable must have this length. A 24-channel cable with an 8-to-10-meter takeout interval is ideal. A 5-meter takeout interval is too short.
c. Only single-channel vertical-motion seismometers (geophones) are needed.
d. Geophones should have a resonant frequency of 8 Hz or less. 12.5-Hz geophones have yielded good results, but 4.5-Hz geophones are needed to assure ReMi velocity resolution to 100 meters depth.
e. A set of 4.5-Hz Mark Products L10B single refraction geophones with 4-inch spikes and 3-foot leads is ideal.
f. Amplitude or frequency-response calibration of geophones is not needed - as with refraction, ReMi uses only the phase information in the recorded wavefield .

2. Siting the Array: Put the cable across your site in a line 200 m (600 ft) long, with about 8 m (25 ft) spacing between phones.

a. You need to locate a reasonably straight stretch of flat ground at your site at least 200 meters long. Center it on your foundation or borehole location if possible.
b. The absolute minimum array length needed for a 15%-accuracy ReMi is 100 meters.
c. Avoid known underground cavities 3 meters or more in diameter - pass beside but not over them.
d. Avoid concrete slabs; thin pavements are OK as long as you are able to set the geophones on them.
e. For ease of deployment, avoid water more than 6 inches deep.
f. An easy urban layout is to run the array along the sidewalk, with the geophones planted into the parking strip or cracks in pavements. If the seismic cable must cross a street or driveways that cannot be blocked during the survey, put it between 2x4s nailed to the pavement. Protect any geophones installed in a street with a traffic cone, or note any channels that cannot be installed.
g. A ReMi array can work extending into the ground floor of a building.
h. For ReMi a deviation in the line of 5%, or 10 m from a 200-m-long line, will not affect the stated 15% velocity accuracy of the method.
i. This accuracy applies to elevations as well - in fact the line can have a constant inclination that can safely be ignored, as long as geophone elevations do not deviate more than 10 m from the incline.

j. Simply chain out the geophone locations with a tape measure.
k. Survey the geophone locations to 1-meter accuracy if the array is more than 10 meters out of line, or 10 meters off constant incline. Include the survey data with the seismic records if this is the case.

3. Installing the Array:

a. Unreel your geophone cable along the array line, setting takeouts at the chained, marked geophone locations.
b. The geophones can be as much as 15 degrees off vertical without compromising ReMi data quality. Visual inspection of verticality is thus adequate.
c. Attach your multichannel seismograph and test for electricalcontinuity, and signal from all geophones.

4. Recording Data: Take 3 to 10 records of background noise, 20-60 seconds long each.

a. Set the record to have 24 channels (if your recorder allows more).
b. Set a time sample interval of 2 milliseconds (ms) or longer, up to10 ms.
c. Set each record to have a time duration of 20-30 seconds. 4 seconds is the absolute minimum. Records longer than 30 seconds can be difficult to translate between formats - configure each recorded trace to have no more than 16,000 samples to avoid such problems (8-sec record at 0.5 ms sampling; 32-sec record at 2 ms sampling; or 160-sec record at 10 ms sampling).
d. Turn off any filtering before digitizing or plotting. If the recorder does not allow this, set the lowest possible low-cut filter frequency (hopefully 4 Hz or less) and a high-cut frequency equal to half the sampling frequency (e.g.: with 2 ms samples, sampling frequency is 500 Hz, so a high-cut filter at 250 Hz is OK as a reasonable antialiasing filter).
e. Record 3 to 10 records, triggered manually. You may want to wait for the passage of a good noise source like a train, heavy trucks, or low-flying jet.
f. Do not stack records in the seismograph's memory. Clear the stack memory before triggering each record.
g. Save each record separately to the seismograph's hard disk, or floppy.
h. Transfer records to a laptop on-site, for easy data transmission later.
i. If the site is quiet, activate some sort of source during each record. Drive up and down the geophone line in a truck. Run up and down the line. Pick up and drop 50-lb rocks. No timing or locating of the source is needed.