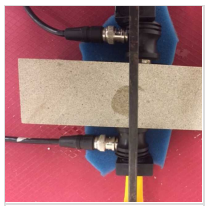

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Measuring Rock Velocities

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ABSTRACT

This protocol describes the measurement of a wave speed using transducers, a function generator, and an oscilloscope.

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GUIDELINES

The hardest part is getting a signal on the oscilloscope. Once you have that signal, you are measuring the time between the trigger and the arrival of the pulse. If you lose the signal, the problem is usually the trigger.

If you are measuring P-waves using S-wave transducers note that this can introduce errors. Please see:

Yurikov, A., Nourifard, N., Pervukhina, M., and Lebedev, M. (2019). Laboratory ultrasonic measurements: Shear transducers for compressional waves.The Leading Edge, 38(5):392–399

MATERIALS TEXT

Rock Samples
Transducers (at least 2 P (V-103) and 2 S (V-153))
3 co-axial cables
oscilloscope
function generator
honey
calipers
clamp

SAFETY WARNINGS

Please do not connect the function generator to the amplifier with output stronger than 4-5 Vpp.

BEFORE STARTING

Collect your materials, ensure your work area is clean and make sure you've told someone you'll be working in the lab.

Pre-experiment setup

1 Measure the sample length with callipers.

2 Attach the transducers to the samples with honey and clamps. For S-wave transducers the polarization is aligned with the direction of the coaxial cable plug. (If you are measuring P-wave velocities with S-wave transducers, please see step 9.)

3 Connect the cables

3.1 Connect one cable from the function generator 'trig out' to the oscilloscope 'ext in' (on the back). This syncs the oscilloscope with the function generator

signal.

3.2 Connect one cable from the output of one channel of the function generator to one of the transducers.

3.3 Connect one cable from the second transducer to one of the channels of the oscilloscope.

4 Setup the equipment.

4.1 Turn on the function generator and oscilloscope.

4.2 On the function generator, set the parameters of the output pulse, including frequency (check the transducers, but typically 1 MHz for the small ones and 100 kHz for the larger ones), amplitude (start at 10 Vpp with no amp).

4.3 On the function generator, check the trigger parameters, typically immed and sync from the channel you have the transducer connected to.

4.4 On the function generator, check the burst settings, typically 1 cycle and 1 burst every 2 ms will work well.

4.5 On the oscilloscope, check the time scale. To cross a 15 cm sample typically takes on the order of 60 us. Press the 'ref' button and put the reference to the left. Check the horizontal scale (larger top knob), set it so that you expect to see the pulse roughly in the middle of the screen.

4.6 On the oscilloscope, check the vertical scale (knob above the channel number). Typically the pulses are small, so you want to zoom in so that it is set to 10-100 mV typically, Turn down the voltage on the function generator until the signal is within the 10-100 mV range.

4.7 On the oscilloscope, press the acquire button, and ensure it is set to averaging and set the number of averages (usually 1-4000).

5 Trouble-shoot: If you see a signal, go to step 6, otherwise try these things:

5.1 Check the trigger on the function generator, make sure it is immed and that it is set to sync with the channel that you have the source transducer connected to.

5.2 Check the trigger on the oscilloscope. Make sure that it is set to 'ext'. Make sure that there is no flashing 'trig?' in the top of the oscilloscope.

5.3 Try changing the 'burst' to 'off'. This will give a continuous signal. If you see something, then you know it is all connected correctly and the problem is then almost certainly the trigger. Once this is working, go back to burst, but use several cycles (say 10) and then return to check the trigger. Once it is working, you can return to one cycle.

5.4 Press the auto-scale button on the oscilloscope. See if this 'finds' your signal.

5.5 If you can see the continuous signal and it seems like the single pulse is too small (e.g. because the continuous signal is only visible with strong zoom), then first ensure you are using 10 Vpp . If you still cannot see the signal, connect the function generator to the amplifier and the output of the amplifier to the transducer. Return to a low amplitude (100 mVpp), and increase until you see the signal or you reach 5 Vpp (max input to the amp).

6 Measure the velocities.

6.1 Once you have a clear signal, ensure that it is at approximately the right time (get a rough estimate of the time from the horizontal scale). If it appears correct, then zoom in on the pulse and turn the small knob on the top until the beginning of the signal lines up with the zero. Look at the time shift on the top of the oscilloscope screen.

6.2 Correct the travel time for the delay induced by the transducers. For our lab, this is 0.3 us for the P-waves and 0.5 us for the S-wave transducers.

6.3 If you do not have a delay time for your transducers, then measure one by measuring the pulse travel time for several different distances through the same material. The travel time delay is the y-intercept of a plot of the travel time (y-axis) as a function of distance (x-axis).

7 Save the waveform. Plug in a USB. Press 'save/recall' on the oscilloscope. Make sure that the format is set to csv, then press save, noting the filename (or changing it to something meaningful).

8 Record the results, including the length, the travel time, the filename and the calculated velocity. If requested measure the density (use a kitchen scale to estimate mass and the callipers to measure lengths and estimate volumes), and compute the elastic constants.

9 Repeat for S-waves and in other directions, as required. If you are measuring P-wave velocities with S-wave transducers, please see the following paper (and expect 5% errors or higher).

Yurikov, A., Nourifard, N., Pervukhina, M., and Lebedev, M. (2019). Laboratory ultrasonic measurements: Shear transducers for compressional waves.The Leading Edge, 38(5):392–399