An experimental venture into micropolar waveguides

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Abstract

This research aims to decipher the interplay between the microstructural length scales intrinsic to granular geomaterials and the wave transmission characteristics of such media over a wide frequency spectrum. In this spirit, the proposed developments are focused on examining the dispersion and attenuation of longitudinal (and flexural) waves in soil specimens of various composition. *Setup*. Fig. 1 illustrates the envisioned sensing configuration, where a cylindrical sample of dried soil is held between a pair of source/receiver (piezoelectric) transducers under a prescribed static prestress (applied e.g. via adjustable clamps). The (source) transducer is then excited by a narrow-band modulated 5-cycle sine burst with carrier frequency f_c and bandwidth $0.1f_c$. Thus-induced wave motion in soil is captured (a) on the other side of the sample with the (receiver) transducer, and (b) over a specified sensing grid along the length of the specimen – via either a high-speed camera (available in the Geotechnical Centrifuge Lab), or a single-point Laser Doppler Vibrometer (LDV), accessible in the Acoustics Laboratory in AES, in which case a mounting fixture endowed with a frictionless sliding track and a step motor must be manufactured to facilitate the movement of the laser head. *Preparation*. The specimen is a periodic assembly of *unit cells* comprised of a certain composition of soil grains (of various characteristic length scales), which may be manufactured (a) by encasing the soil assembly in a plastic wrap of infinitesimal thickness; in which case, many elements of preparation are shared with that of the triaxial testing of dry soil, and (b) via sequential processing where (dry) soil particles are first assembled in a suitable container; the sample is then saturated (either by water or meta-cellulose) and subsequently oven-baked; thus-obtained (dried) column of soil retains its shape for the purpose of dynamical testing. This procedure caters for the full-waveform measurements via the high-speed camera or LDV. *Image processing*. A high-fidelity algorithm/code rooted in Particle Image Velocimetry (PIV) is then developed aiming to map the image sequences captured by the high-speed camera (if applicable) into the particle velocity distribution (in time and space) on the soil surface. *Signal processing*. A cross-correlation technique is invoked to determine the phase shift between the measured signals at multiple scan points (for better accuracy), that is eventually used to estimate the *phase velocity* at a given carrier frequency f_c. In this setting, the dispersion curves are constructed experimentally by repeating the measurements over a desired span of carrier frequencies f_c. Moreover, the attenuation coefficient can be computed by tracing the evolution of *peak* amplitude through the length of the sample. For validation purposes, one may also compare the peak amplitude of the input burst with the signal eventually recorded by the receiver on the other side of the soil sample. The results will be used to validate the outcome of the analytical and computational campaigns in progress parallel to the development of the experimental side.

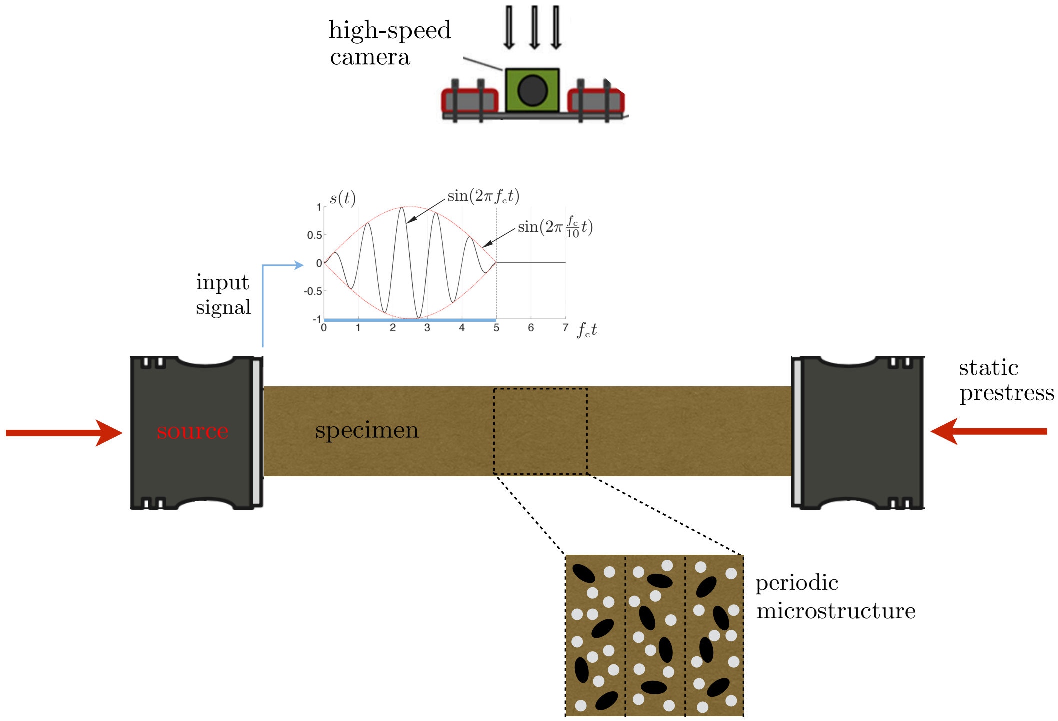

Figure 1. Sensing configuration.