Soil elastic characteristics: from pseudo- static behavior to ultrasound propagation

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The present study establishes the link between ultrasonically determined elastic moduli and those obtained by small stain mechanical testing. It is shown by laboratory testing that, using Biot's equations, moduli determined by the two previous techniques are identical. This result paves the road to geophysical measurements of in situ soil elastic moduli, E and G.

This conclusion has been obtained by means of many laboratory technique enhancements. Ultrasonic measurement methodology has been studied. General rules for the design of ultrasonic transducers are proposed and soil specific signal frequency domain of validity are defined. Mechanical testing technique has been improved by achieving a strain transducer resolution of 0.01 µm and by lowering their weight below 5 g. These modifications led to unmatched levels of precision in triaxial cell.

Furthermore, a laboratory technique has been set up to determine the value of a parameter (used in porous media ultrasonic wave propagation equation). This parameter has never been evaluated before. It is also shown that over frequencies of 200 kHz, two fast P waves coexist. The first one is the traditional P wave. The second one is a wave that propagates in the same porous medium but with a saturating fluid compressibility equal to 1/10th of its theoretical value. This phenomenon is attributed to the presence of micro air bubbles. Both waves indicate similar elastic moduli, allowing two simultaneous measurements of them.

Two soil types were used in this study, namely a quartz sand and a silty sand. Samples from a borehole executed on the EPFL campus were also tested.

It is also explain how, from in situ elastic moduli determination and from laboratory test, it is possible to calculate in situ soil behavior to higher strains (up to 1%) using Masing rule. This extends the domain of interest of elastic moduli.