EXTENSION OF THE POROELASTICY THEORY TO ADDRESS IN-SITU STRESS IN SHALLOW SUBSOIL

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The poroelasticity theory of Biot and its many modifications and extensions have so far been used in rock physics and soil physics to explain and exploit frequency-dependent propagation of seismic waves through a porous subsurface layer. The physical properties that have been associated are hydraulic/flow properties like porosity, permeability, viscosity and tortuosity. Poroelasticity has not been used to address the level of in-situ stress.

In the context of shallow subsoil characterization, we have performed laboratory tests on water-saturated sand where we have measured frequency-dependent seismic wave velocity (especially S-wave velocity because of its geotechnical importance) for various levels of in-situ horizontal and vertical effective stresses. In order to understand our experimental data, the poroelastic stress-strain relations and the wave equation in full anisotropic case have been revisited. On the other hand, we have employed micromechanical theories or stress-porosity-rigidity relations to introduce stress-dependence in the poroelastic material properties. This has resulted in, for the first time, varying levels of velocity dispersion for varying stress levels, as we indeed observe in our experiments. The theory has been developed for isotropic and transversely isotropic (VTI) media. Since spatial wavenumber is involved, the dependence of seismic dispersion on the direction (angle) of wave propagation can be described. Finally, when the porosity is known, we can invert the value of in-situ stress and permeability from the observed seismic dispersion and attenuation in the field seismic frequency range.