F4. Hydraulic effects

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1. **Hydromechanical coupling**

Another peculiarity of geotechnical calculations concerns the role of water in soils. When a mechanical load is rapidly applied to a saturated layer of soil, instantaneous deformation, and pressurization of the fluid in the vicinity of the applied load occurs. Depending on the hydraulic boundary conditions, the gradient of the hydraulic load causes the fluid to be set in motion, leading to pressure redistribution and delayed deformation of the soil.

Therefore, a problem of hydromechanical coupling must be dealt with. A solid theoretical framework was established by Biot (1941) and developed by Coussy (1991). In terms of numerical resolution, the coupled problem is much more difficult to deal with than a classical problem, for several reasons:

- the problem involves, in addition to displacements, a new unknown field, the water pressure field,
- it is necessary to specify boundary conditions specific to the hydraulic problem (define the parts of the contour that are impermeable and those where pressure is imposed),
- the solution (in displacement and pressure) is time-dependent,
- the mathematical nature of the problem to be solved is different,
- the permeability of the different soil layers must be described quantitatively.

Complete processing of the hydromechanical coupling is rarely performed. One generally tries to limit oneself to a decoupled approach to the problem, in which one calculates the evolution of the pressure field while neglecting the deformations of the solid. However, this decoupling has the consequence of strongly underestimating the duration over which the pressure redistribution occurs.

2. **Unsaturated soils**

The treatment of unsaturated soils complicates even more the problem as the transition from near-saturated to unsaturated zones introduces additional unknowns, non-linearities, and parameters. Again, the complete treatment of unsaturated soils remains rare. It is preferred to propose simplified solutions, neglecting partially saturated zones for example.

Defining the initial state in the case of unsaturated soils is extremely complex because of the lack of experimental methods to characterize it in situ.

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