Contribution ID: **776** Type: **Poster (+) Presentation**

Theoretical analysis of poroelastic response of spherical indentation into a half space via step-displacement loading

Tuesday, 1 June 2021 19:00 (1 hour)

The process of indentation by a rigid tool has been widely studied for its versatility as an experimental technique to probe constitutive properties of materials of various kinds across multiple scales. Recently the technique has been applied to characterize poroelasticity of soft materials such as polymeric gels via load relaxation experiments, where an indenter is pressed instantaneously to a fixed depth and held until the indentation force approaches a horizontal asymptote. Assuming incompressibility in both the solid and fluid phases, elastic constants are determined from the early and late time responses, while the hydraulic diffusivity is obtained from the transient response by matching the experimentally obtained indentation force as a function of time against a master curve obtained from FEM simulations [1]. The numerical analysis assumes a negligible effect of the Poisson's ratio and a mixed drainage surface condition where the area underneath the indenter is impermeable while the region outside is fully drained.

Motivated by these experimental advances in soft materials, we analyze indentation of a poroelastic solid by a spherical-tip tool within the framework of Biot's theory. The McNamee-Gibson displacement function method is employed to solve the cases where the indenter is subjected to a step displacement loading. Three types of surface drainage conditions, namely, fully drained, fully undrained and mixed drainage, are analyzed. Compressibility of both the fluid and solid phases is considered in these solutions. Though derivation of these theoretical solutions requires the aid of a variety of mathematical techniques to overcome the difficulties related to integrals with rapidly oscillating kernels and solving the Fredholm integral equation of the second kind, the results in terms of the normalized indentation force relaxation with time are remarkably simple. The transient force responses show only weak dependence on one derived material constant and can be fitted by elementary functions, which lend themselves to convenient use for material characterization in the laboratory.

Time Block Preference

Time Block C (18:00-21:00 CET)

References

1. Y. Hu, X. Zhao, J. J. Vlassak, and Z. Suo. Using indentation to characterize the poroelasticity of gels. Applied Physics Letters, 96(12):121904, 2010.

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