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On the Pressure Generation anRelaxation in a Porous Media under a Spherical Loading Surface

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The phenomenon of pressure generation and relaxation inside a porous media is widely observed in biological systems. For example, the pressurization inside the cartilage plays the key in the load bearing and lubrication of the knee joints. In this paper, we report a biomimetic study to examine the transient pressure distribution inside a soft porous layer when a spherical loaded surface suddenly impacts on it. A novel experimental setup was developed that includes a fully instrumented spherical piston with supporting structures, and a soft fibrous porous layer underneath. The materials were precisely characterized on their porosities, pore sizes, fiber stiffnesses and permeability. Extensive experimental studies were performed with different porous materials, different loadings and different sized loading surfaces. The pore pressure generation and the motion of the loading surface were recorded by pressure transducers and laser displacement sensors, respectively. A novel theoretical model was developed to characterize the process of the pore pressure generation and relaxation underneath the loading surface and inside the undeformed surrounding materials. Excellent agreement was observed between the experimental results and the theoretical predictions. It clearly demonstrated that the hydrodynamic similarity between porous media on different scales are governed by the Brinkman parameter, $\alpha = h/K_p^{0.5}$, where h is the porous layer thickness, and K_p is the undeformed Darcy permeability. The study significantly improves our understanding of the dynamic response of soft porous media under rapid compression, which has broadd impact on the study of transient load bearing phenomenon in biological systems and industry applications.

References

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