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1. INTRODUCTION

Poroelastic materials are widely used for acoustic treatments due to their efficient sound absorption. Granular materials present also interesting properties according to nonlinear wave propagation and attenuation and their ability to cope with the transmission of vibrations and mechanical shocks. In this work, we study the properties of poroelastic spheres made of polymer foam. The objective is to determine the contact stiffness between a poroelastic sphere and a rigid plane, the aim being to homogenize a poroelastic granular material for sound propagation.

2. MEASURMENT

First, we present experimental results obtained with poroelastic half-spheres, made of the same materials (melamine foam) but with different radii R. They are subjected to a quasistatic strain imposed by the displacement δ of a rigid plane. The experimental set-up is presented in Fig. 1. The lens allows carefully setting the reference position at which the half sphere (Sample) starts to be in contact with the rigid plane (Still plate).

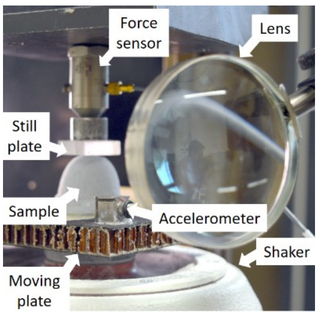

Figure 1. Experimental set-up for quasistatic measurement of the contact force of a melamine half sphere sample.

The results presented in Fig. 2 show two regimes: a nonlinear Hertzian regime at high strain corresponding to a displacement higher than 200 µm, which is radius-dependent, preceded by a regime common to all samples at low strain, which relies on the features of the surface.

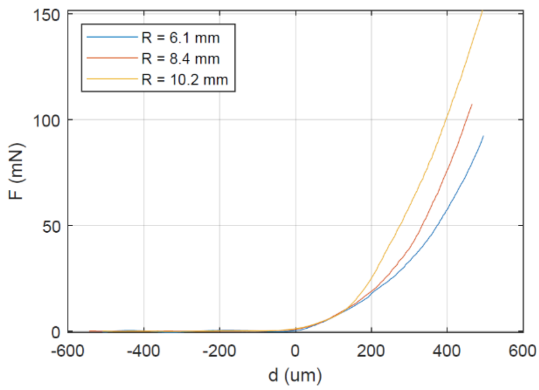

Figure 2. Force as function of displacement for 3 half spheres of different radius.

3. SIMULATION

The limit between the two regimes is further studied by a numerical approach using a finite element model of a representative volume. The poroelastic grain is modeled by asymmetrical Kelvin cells within Abaqus software and takes into account the geometrical non-linearity during the deformation. Fig. 3 shows a detail of the numerical model at the contact location between the sphere and the plane.

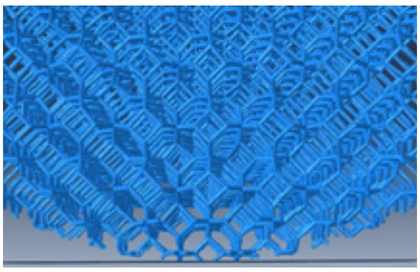

Figure 3. Detail of the model at the contact point between the rigid plane and the half sphere modeled by Kelvin cells.

Fig. 4 shows that above a given displacement the Hertz law applies: $F = c\,ER^{1/2}\delta^{3/2}$, where E is the Young's modulus of the porous material and c the prefactor. Before this limit, no general tendency can be given since the results is function of the number of contact points between the ligaments and the plane.

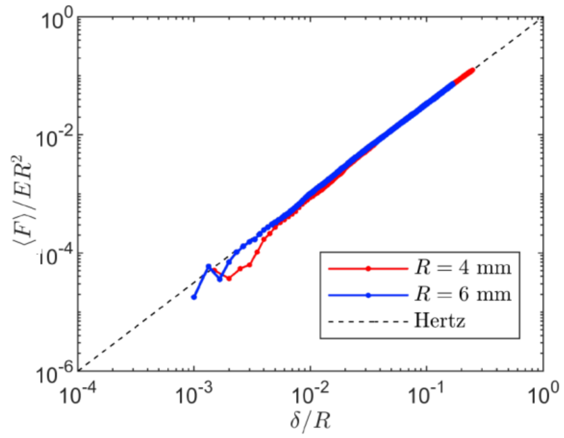

Figure 4. Numerical results: force F as function of displacement δ.

More details are available in International Journal of Solids and Structures, "On the contact law of open-cell poro-granular materials" co-authored by C. Hentati, S. Job, J.-P. Crété, M.Taktak, M. Haddar and N. Dauchez, 2020 https://doi.org/10.1016/j.ijsolstr.2020.10.023