OPTIMIZATION IN BEAD PACKING WITH ELASTO-PLASTIC BEHAVIOR

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An optimization scheme for the tailored energy propagation through a two-dimensional quadrangular packing of spherical beads is proposed. Flexibility in prescribing the bead material properties and introducing interstitial beads, i.e. *intruders*, give this system favorable characteristics for energy wave management. We recently developed an optimization scheme in which the contact interaction between beads is modeled using an non-linear elastic Hertz contact law. Design variables in the optimization include the presence (or non-presence) of intruders within the voids of the quadrangular bead packing and the material properties of the beads. In order to make the problem tractable, we convexify the design space. Indeed, the intruders presence (or non-presence) and their material properties are represented by discrete valued design parameters. We replace such variables with density like variables and use the solid isotropic material with penalization (SIMP) technique to recover the discrete design representation.

Our current goal is to incorporate residual plasticity into the material model by using an empirical one dimensional law that describes the history dependent contact interaction between the beads. The transient analysis is performed using the Newmark method and an additional constitutive equation is introduced to evolve the state variables, i.e. the bead's plastic deformation. Sensitivities are calculated using an adjoint method for the coupled transient analysis similar to the method used in [1]. The problem's constraints are the total number of intruders which can be likened to total packing weight and manufacturability. An interior-point algorithm is used to perform the optimization. Results obtained from both the elastic and elasto-plastic case are compared.

References

[1] D. A. Tortorelli P. Michaleris and C. A. Vidal. Tangent operators and design sensitivity formulations for transient nonlinear coupled problems with applications to elastoplasticity. *International Journal for Numerical Methods in Engineering*, 37(14):24712499, 1994