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MULTI-PHYSICS MODELING AND SIMULATIONS OF THERMALLY-ASSISTED COMPACTION OF GRANULAR MATERIALS

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Designing materials, based on the required properties of the end product, is a topic of great current interest. Consolidation of granular materials, which is important to vast array of industries, has sparked considerable recent research.This study is also contrived to bridge the fundamental understanding of particle-mechanics to macro-scale applications.

We present a mathematical formulation that couples the thermal and mechanical behavior of a discrete system of particles. Integration of thermal expansion experienced by the compacted particles increases the challenge in the thermo-elastic contact problem. Numerical simulations are evaluated for quasi-static equilibrium and steady state heat conduction that are appropriate in most of the engineering practice. With understanding this coupled problem's characteristics, we elaborated the continuum theory and derived effective thermal expansion coefficient that also accounts for the macroscopic results. To demonstrate the predictive potential of these models, we present specific applications in the analysis of three fundamental problems (i) testing proposed method for calculation of effective thermal expansion, (ii) formation of hot zones, stress and heat chains as preferred paths in the granular media, (iii) exploration of thermal expansion's role during thermally-assisted compaction of granular materials which also undergoes phase transformation.

The nonlinearity of the multi-physics problem reveals various interesting aspects unique to granular matter. In this regards, it is worth noting that the results of the proposed thermo-mechanical model depart from those of conventional compaction models based on a continuum mechanics description.