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Arching in Granular Media

Radoslaw L. Michalowski[(1)], Namgyu Park[(2)]

(1) *University of Michigan, USA*
(2) *Texas A&M University, USA*

Arching in sand piles can cause a counterintuitive stress depression (a “dip”) at the center of a conical or a wedge-shaped pile. However, predictions of the degree to which the granular material will arch are not easily made. A framework of plasticity analysis is used to shed some light on the issue of arching in granular media. Arching is characterized by a stress distribution where the load is transferred from softer to stiffer regions of a structure, forming a stable configuration. Since it is a stable “arrangement”, arching is not a typical limit state problem. However, it can be formulated in a manner that allows using the static theorem of limit analysis to assess the likelihood of arching. The theorems of limit analysis can be rephrased to indicate when arching may, and when it will not occur. Radial stress fields are constructed to search for stress distributions that promote arching. Governing equations are derived for radial stress distributions with regions varying from the yielding stress state to the elastic stress state. The stress fields with an elastic core promote arching, whereas the field where all material is in the active limit state does not support arching. Characteristics of arching in sand piles do not confirm the stereotypical view that arching is associated with a transfer of load from yielding parts of the structure to the stiffer parts. It appears that equally plausible arching stress fields are ones where the load is transferred over the sand that has not reached the yield state.

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