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Evolution of unsaturated hydraulic conductivity of aggregated soils during compression

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Prediction of water flow and transport processes in soils susceptible to structural alteration such as compaction of tilled agricultural lands, or newly constructed landfills rely on accurate description of changes in soil unsaturated hydraulic conductivity. Recent studies have documented the critical impact of aggregate contact characteristics on water flow rates and pathways in unsaturated aggregated soils. We developed an analytical model for aggregate contact size evolution as a basis for quantifying effects of compression on unsaturated hydraulic conductivity of aggregated soil. Relating confined one-dimensional sample strain with aggregate deformation facilitates prediction of the increase in inter-aggregate contact area and concurrent decrease in macro-pore size with degree of sample compression. The hydrologic component of the model predicts unsaturated hydraulic conductivity of a pack of idealized aggregates (spheres) based on contact size and saturation conditions under prescribed sample deformation. Calculated contact areas and hydraulic conductivity for pairs of aggregates agreed surprisingly well with measured values, determined from compaction experiments employing Neutron- and X-ray-radiography and image analysis.