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# Micron-scale mechanical properties of soil aggregates amended with manure: experimental evidence and image-based finite element simulations

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Soil aggregates fracture through the coalescence of internal macropores (cracks), forming smaller fragments that change pore structure characteristics. Many studies have measured soil aggregate fracture with laboratory tests, but the impact of internal pore structure has remained elusive in the black box of soil. This study, which is the first of its kind, uses Xray micro-CT imaging, mechanical measurement experiments and finite element simulations to investigate the relationship between soil pore-scale topology and aggregate mechanical properties including fracture energy. The soil aggregates came from a red soil (Acrisols) experimental field in Jiangxi, China that had been amended with different amounts of manure and lime. From Xray micro-CT, quantitative topology analysis extracted the pore network extraction method. Then the strain-stress relationship and fracture energy of the scanned aggregate were measured using a loading frame. The micro-CT images are used as geometry inputs to perform finite element methods to calculate effective Young's modulus and detailed strain-stress distribution at micrometers. The experimental results showed that adding manure increased the elastic stiffness and fracture energy of the aggregate. The pore scale strain-stress distribution analysis from finite element simulations found these properties at aggregate scale were weakly correlated to bulk porosity but driven by the stress intensity distribution of the aggregates, agreeing with previous research on model soil structures.