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Mechanical interactions between neighbouring roots

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The presence of root networks on steep hillslopes stabilizes the soil and reduces occurrence and intensity of shallow landslides. Methods for quantification of root reinforcement are important for developing hazard mitigation strategies. The simples method is the Wu model that considers uniform cohesion-like reinforcement whereas more recently detailed models considering root size distributing and geometry of root systems have been proposed based on the Fiber Bundle Model. Questions remain regarding mutual mechanical behaviour of clusters of roots on reinforcement characteristics. The objective was to quantify the mechanical interactions among neighbouring roots or roots networks using modelling approaches and pullout laboratory experiments. Based on simple geometrical characterization of individual root geometry, we calculated the 2D dissipation of root-soil interfacial frictional stresses in radial and longitudinal directions. Using linear superposition of shear stresses within the soil matrix we were able to quantify the range of roots densities at which the radial mechanical interaction could influence the global pullout behaviour of the root bundle. The model was compared with laboratory pullout test results for parallel root bundles with densities corresponding to inter-distances of 15, 35 and 105 mm. In addition, effects of root crossing for bundles with 105 mm root inter-distance were measured. All experiments were conducted for branched and unbranched roots.
Results show insignificant differences in root pullout behaviours between tested root densities and crossing geometry. A decrease in the mean pull out force of 17% was observed for high root densities (> 1000 roots/m3). Moreover, the results show that the influence of the branching points on maximal pullout force of the bundle is statistically significant. This study quantified effects of root densities and delineates the limits of applicability of the assumed non interacting roots implicit in the FBM.