

ABSTRACT

Activities of microbes within subterranean environments are known to influence aggregation of mineral particles. Microbe-mediated soil aggregation has been harnessed by geotechnical engineers in a variety of applications including erosion control, dust control and mitigation of liquefaction hazard. Although aggregation of mineral grains is expected to be controlled by chemical interaction between extracellular metabolic products resulting from microbial activities in the subsurface environment, investigations on these interactions on soil grain aggregation has been very limited. In this research, a number of species of soil-residing bacteria with noticeable capabilities of aggregating soil particles through production of extracellular polymeric substances (EPS) and minerals in the presence and absence of urea in the nutrient media were isolated and identified. Loose and dense water pluviated sand samples hosting these microbes sustained with different compositions and doses of nutrients were subjected to drained and undrained triaxial tests in the laboratory to assess the influence of the activities of these species on deformation behavior of sand. Loose sand samples were found to exhibit greater dilatancy and shear strength than those for similar but biomass-free samples. Test data for these samples indicated development of effective stress cohesion intercepts. Unsaturation introduced by CO₂ produced by the microbes also resulted in a significant decrease in pore water pressure generation potential under undrained conditions. Although dense samples also developed cohesion intercepts at pre-failure deformation levels, microbial activities failed to improve the drained shear strengths and dilatancy appreciably. Compositions of extracellular metabolic products appear to explain the observed enhancements in mobilized deviator stress and changes in volumetric behavior. Data obtained in this research indicated that interaction between soil particles and extracellular metabolic products was controlled by their amounts, compositions and chemical and physical environmental parameters, e.g., pH, media flow rate and nutrient availability. Shake table and model soil erosion tests conducted in the laboratory indicated that activities of minimally sustained microbes turned loose sand more resistant against cyclic liquefaction and piping and erosion. It therefore appears that activities of minimally-sustained endemic strains of soil bacteria could be harnessed as sustainable and eco-friendly mitigation measures against water erosion and liquefaction problems.

Keywords: Microbial metabolic products, soil aggregation, deformation behavior, EPS, calcite, cemented sand, shear strength, dilatancy, cohesion, erosion, liquefaction, shake table