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Biogeochemical Reactive Transport Model for Denitrification-Driven Ground Improvement

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We are developing a multiphase reactive transport model for denitrification-driven ground improvement to account for the dominating influence of the complexities expected in the field, including biochemical process competition, microbial inhibition, and complicated soil conditions. Denitrifying bacteria are ubiquitous in most subsurface environments, and denitrification is a common process in anaerobic environments. Since denitrification is feasible regardless of location, microbially induced desaturation and precipitation via denitrification (MIDP) has widespread potential for ground improvement, particularly earthquake-induced liquefaction. Inorganic carbonate precipitates as calcium carbonate minerals in presence of dissolved calcium ions, shown to increase strength and stiffness and reduce permeability in the subsurface. Biogenic gas production reduces the degree of saturation and permeability and increases the compressibility of the pore fluid for liquefaction mitigation. Previous MIDP models have represented the biogeochemistry well, but the flow conditions have been very simple – batch or homogeneous 1-D transport – or did not consider biochemical reactions seen under field conditions. Field testing has shown that these simplistic models do not account for natural field conditions experienced in the field that influence the uniformity of MIDP treatment and the spatial distribution of MIDP products, both of which are crucial for ground improvement. Our model considers stratified soil conditions, competing biochemical reactions, groundwater composition, and by-product accumulation. The influence of these mechanisms will be addressed so that predictions of the performance of field-scale MIDP treatment is comprehensive and treatment designs account for the complex soil environment.