The effects of rainfall-induced seepage on slope stability

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The tacit assumption made in the majority of liquefaction analyses is that no change in volume occurs prior to the initiation of pre-failure instability. However, evidence from geotechnical case studies and physical model tests suggest that granular slopes, because of their high permeability, can undergo localised dilation, even during relatively brief rainstorms. The potential for the development of instability under partially drained conditions is therefore of considerable practical importance, particularly when it may have consequences that are more severe than those occurring under undrained conditions.

An experimental investigation of the effects of pore-water migration on the initiation of pre-failure instability in a saturated sand is presented. The domain of stress space in which instability develops is identified under various strain-paths, and its relationship to the zone of instability observed during undrained shear is explored. Results demonstrate that water content redistribution may render a sand unstable that would otherwise stabilise at the quasi steady state during undrained deformation, implying that the presumption of undrained conditions cannot always be regarded as conservative. Thus, partially drained conditions that result in even very small dilative volumetric strains can trigger instability at constant shear stress that would not develop if conditions remained undrained without some initial increase in shear stress.

Pre-failure instability is affected not only by the initial state of the sand but also by the strain increment ratio imposed during shear. The response is controlled mainly by the difference between the imposed strain increment ratio and the maximum strain increment ratio obtained from a drained test conducted under the same initial effective stresses. In very loose sands, for example, the maximum strain increment ratio is typically greater or equal to zero and instability tends to occur under undrained conditions. However, in dense sands with a negative maximum strain increment ratio instability is possible only when the imposed strain increment ratio is more negative. The relevance of the insitu stress conditions, the preloading history and the kinematic constraints on the collapse mode are discussed.