LIQUEFACTION EFFECTS ON STRUCTURES

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Liquefaction has caused significant damage of buildings with shallow foundations. In recent earthquakes, buildings have punched into, tilted excessively, and slid laterally on cyclically softened ground. The state-of-the-practice still largely involves estimating building settlement using empirical procedures developed to calculate post-liquefaction, one-dimensional, consolidation settlement in the free-field away from buildings. Performance-based earthquake engineering requires improved procedures, because these free-field analyses cannot possibly capture shear-induced and localized volumetric-induced deformations in the soil beneath shallow foundations. Recent field case histories, experiments, and numerical modeling have provided useful insights. Differential settlement of shallow-founded structures is often governed by liquefaction of shallow soils and the loss of ground due to the development of sediment ejecta. Geotechnical centrifuge tests reveal that much of the building movement occurs during earthquake strong shaking and its rate is dependent on the shaking intensity rate. Additionally, shear strains due to shaking-induced ratcheting of buildings into cyclically softened soil and volumetric strains due to localized drainage in response to high transient hydraulic gradients are important effects that are not captured in current procedures. Nonlinear effective stress analyses can capture the soil and building responses reasonably well and provide valuable insights. Based on these studies, recommendations for estimating liquefaction-induced movements of buildings with shallow foundations are made.