LIQUEFACTION-INDUCED BUILDING MOVEMENTS

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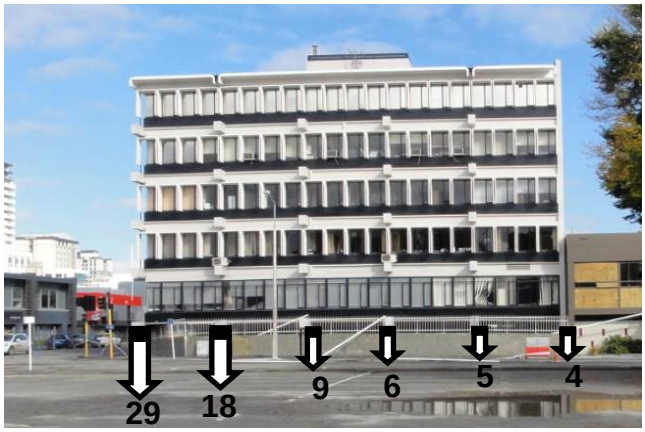
Liquefaction or ground softening from earthquake shaking have caused significant damage of buildings with shallow foundations. In recent earthquakes, buildings have punched into, tilted excessively, and slid laterally on liquefied/softened ground. The state-of-the-practice still largely involves estimating 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 underneath shallow foundations. Recent physical and numerical modeling has provided useful insights into this problem. Centrifuge tests revealed that much of the building movement occurs during earthquake strong shaking and its rate is dependent on the shaking intensity rate. Additionally, deviatoric strains due to shaking-induced ratcheting of the buildings into the 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 with the UBCSAND constitutive model implemented in FLAC 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.

Adapazari, Turkey (1999 Kocaeli EQ)



(Settlement in cm)

Christchurch, New Zealand (2011 Christchurch EQ)