Osterberg Lecture:

Estimating Liquefaction-Induced Building Settlement

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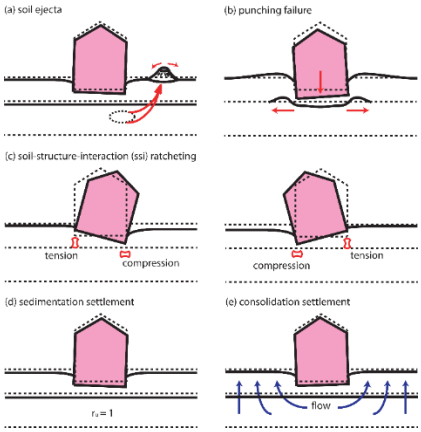
ABSTRACT: Significant settlement and damage may occur due to liquefaction of soils beneath shallow-founded buildings. The primary mechanisms of liquefaction-induced building settlement are shear-induced, volumetric-induced, and ejecta-induced ground deformation. Volumetric-induced free-field ground deformation may be estimated with available empirical procedures. Although challenging to estimate, ground failure indices and experience can be used to estimate roughly ejecta-induced building settlement. Nonlinear dynamic soil-structure interaction (SSI) effective stress analyses are required to estimate shear-induced ground deformation. Results from over 1,300 analyses identified earthquake, site, and building characteristics that largely control liquefaction-induced building settlement during strong shaking. A simplified procedure was developed based on the results of these analyses to estimate the shear-induced component of liquefaction building settlement. The standardized cumulative absolute velocity and 5%-damped spectral acceleration at 1 s period capture the ground shaking. The liquefaction building settlement (LBS) index, which is based on the shear strain potential of the site, captures in situ ground conditions. Building contact pressure and width capture the building characteristics. Field case histories and centrifuge test results validate the proposed simplified procedure. Recommendations and an example for evaluating building performance at liquefiable sites are shared.



Liquefaction-induced building displacement example (left) and mechanisms (right): (a) ground loss due to soil ejecta; shear-induced settlement from (b) punching failure, or (c) SSI ratcheting; and volumetric-induced settlement from (d) sedimentation or (e) post-liquefaction reconsolidation (Bray and Macedo 2017).

an Bray, Ph.D., P.E., NAE is the Faculty Chair in Earthquake Engineering Excellence at the University of California, Berkeley. Dr. Bray is a registered professional civil engineer and has served as a consultant on important engineering projects and peer review panels. He has authored more than 350 research publications on topics that include liquefaction and its effects on structures, seismic performance of earth structures, earthquake ground motions, and earthquake fault rupture propagation. He created and led the Geotechnical Extreme Events Reconnaissance (GEER) Association. Dr. Bray is a member of the US National Academy of Engineering and has

received several honors, including the Terzaghi Award, Ishihara Lecture, Peck Award, Joyner Lecture, Middlebrooks Award, and Huber Research Prize.