Some Geotechnical-Related Issues for Existing Engineered Buildings

Communication

This comment is a philosophical issue, rather than a research need. Quite often, the geotechnical engineer is left to operate in a vacuum by the architect and/or structural engineer with regard to building information (e.g., existing column loads) and retrofit/rehabilitation plans (e.g., configuration changes, performance objectives, anticipated design loading conditions), being asked only for bits and pieces of information (e.g., allowable foundation bearing stresses, friction, and passive resistance; sometimes soil-foundation springs), rather than being involved as an integral participant in the evaluation and design process. Better interaction and idea sharing as an inclusive team is needed; this likely would lead to a smoother evaluation and design process and produce more appropriate and effective overall building retrofit/rehabilitation for the desired performance objectives.

Factors of Safety versus Load-Deformation Relationships

We should minimize the use of the notion of factor of safety to define an “allowable” bearing stress or capacity for a foundation element and encourage folks to develop and utilize load-deformation (or deflection) characteristics for the soil-foundation system and define “allowable” based on an acceptable deformation (or deflection) criterion. Many geotechnical engineers don’t know or understand the fundamental basis of allowable bearing stress and the magic factor of safety of 3 on ultimate bearing capacity to get there; it was/is, in fact, controlled by acceptable deformation. Load-deformation (or deflection) relationships developed for the soil-foundation system elements provide the bases for the foundation modeling parameters (e.g., springs) used for structural analyses of a building, so we should just go that route. Use of load-deformation relationships will also help ensure that deformation compatibility is being maintained (or at least considered) when defining springs to model different elements of the foundation system or combining resistances for different elements.

The relationships should accurately reflect the expected characteristics and their variability and separate relationships likely should be developed to represent gravity loading conditions and seismic loading conditions. These latter relationships should incorporate appropriate strain-rate (or rate of loading) and cyclic effects on the soil shear strength and modulus, as opposed to using the arbitrary ⅓ increase that is commonly applied across the board; strain-rate effect differs by the type and nature of the soil, from negligible to very little for some soils to 50% or greater for other soils. In projecting expected capacities and load-deformation characteristics, it is important to understand the bearing pressures that the foundations are exhibiting under the building gravity loads and/or have experienced during past seismic loading conditions and whether the foundations have performed adequately, and use these as a check of the reasonableness of the estimated relationships.

Lastly, just as an example of accurate reflection of expected load-deformation characteristics, the lateral resistance mobilization curve for passive pressure given in ASCE/SEI 41-06 is far too soft to appropriately represent stiff or dense soil or fill materials.

Liquefaction

Liquefaction is not a black or white, yes or no, issue as it is frequently portrayed. Yes, occurrence of liquefaction of soils at and/or below the foundation support level can result in deleterious effects on building performance due to significant loss of foundation bearing support capacity and stiffness and large post-earthquake differential settlement; these effects are usually considered and their evaluation and mitigation are addressed in relevant codes and standards (e.g., ASCE/SEI 41). Often, when a geotechnical engineer determines (using whatever method of assessment) there is not a potential for liquefaction at a site, he/she drops the issue and moves on to other considerations.

What is commonly not addressed, however, are cases for which liquefaction is not expected to occur for the ground shaking conditions being utilized, yet the soil behavior aspects that lead to occurrence of liquefaction can still generate and accumulate relatively high levels of excess pore water pressure, to which substantial reductions of soil shear strength and modulus may be associated that *should not be* *ignored*. The potential for such reductions and their implications to soil-foundation system stiffness and capacity characteristics can be speculated upon, but there is no systematic approach to estimating those effects; it seems that it would be important to understand the potential for these effects and capture them in developing the foundation modeling parameters (e.g., springs) used for structural analyses.

Ground Modification and Foundation Systems

There are numerous innovative systems that have been and are being developed that may have valuable applicability to retrofit/rehabilitation of existing buildings. While the virtues of these systems are being touted to building owners by their developers and sales representatives as the next best thing since sliced bread, there is very limited performance experience for many of these systems for design-level seismic conditions. Additionally, many of the newer and/or more innovative systems are proprietary and require a design-build approach to their implementation; while not necessarily an issue for private-sector projects, this is a considerable issue for public-sector projects. Analysis, testing, and evaluation of promising systems in a controlled and unbiased environment, would be desirable to assess the seismic-worthiness of such systems before implementation and being put to the ultimate test of a design-level earthquake.

Lateral Earth Pressures

Basement walls, retaining walls, soil/fill conditions behind the wall. There are many questions, fewer answers, and perhaps as many approaches to computing dynamic earth pressures as there are geotechnical engineers.

Site Response Coefficients at Stronger Ground Shaking

Adjustments to the ground motions to account for site response effects of the subsurface profile (i.e., Site Class) at a given building site can be made using site response coefficients F_a and F_v. These site response coefficients are given by various codes and standards (e.g., ASCE/SEI 41-06), corresponding to short-period ground motions (F_a for PGA and S_S) and longer-period (i.e., T=1 second) ground motions (F_v for S_1). For short-period ground motions (e.g., PGA and S_S), these codes and standards provide site response coefficients that vary with ground motion level for PGA values up to 0.5g and S_S values up to 1.25g, with the coefficients held constant at higher ground motion levels; similarly, for longer-period ground motions (e.g., S_1), site response coefficients that vary with ground motion level for S_1 values up to 0.5g are provided, with the coefficients held constant at higher ground motion levels. Characterization of site response effects in accordance with the coefficients F_a and F_v unfortunately does not reflect the potentially-significant nonlinear ground response characteristics that soils can exhibit at stronger ground shaking levels (e.g., with PGAs exceeding 0.5g), especially for soils in Site Classes D and E, and, as a result, the coefficients may not adequately reflect the significant deamplification of shorter-period spectral accelerations (including peak ground acceleration) that can be affected by nonlinear soil behavior at higher levels of ground shaking. Buildings at sites underlain by such conditions may, therefore, be undergoing evaluations for ground shaking conditions estimated to be 10% to 20% greater than may actually be experienced by the site and building retrofit/rehabilitation measures design accordingly.

We also note that the site response are not necessarily consistent with site response effects that would be calculated using the Next Generation Attenuation (NGA) relationships that the seismic hazard maps currently in use as design tools are based on.

Code Spectral Shape

The shape of the longer-period portion of the General Horizontal Response Spectrum, controlled by 1/T, is probably not representative of spectral characteristics of seismic hazard for many tectonic environments (e.g., Stable Continental Regions) in the United States. This may affect the ground motion levels estimated for buildings with mid-range to longer-period modes of vibration.

Others…….