Earthquake-safe Buildings

Article 2. Avoiding Soil and Foundation Problems during Earthquakes

Ideally, each of us would like our house or building we occupy to be founded on solid rock. If so, we would eliminate several potentially serious soil failure scenarios affecting our building. During earthquake shaking, soil can behave in ways that are not only strange but dangerous to buildings.

Perhaps the most obvious hazard arises from steep slopes. They are susceptible to rockfalls and landslides, both of which can destroy individual buildings and whole communities. Usually, civil engineering solutions are found to prevent these problems. For example, surface drains can prevent rainwater softening the soil of potential slips that earthquake shaking might activate. Active stabilization of a hillside involving drilling long holes and installing 'ground anchors' to prevent a slip forming involves a greater level of intervention and investment (Figure 1).

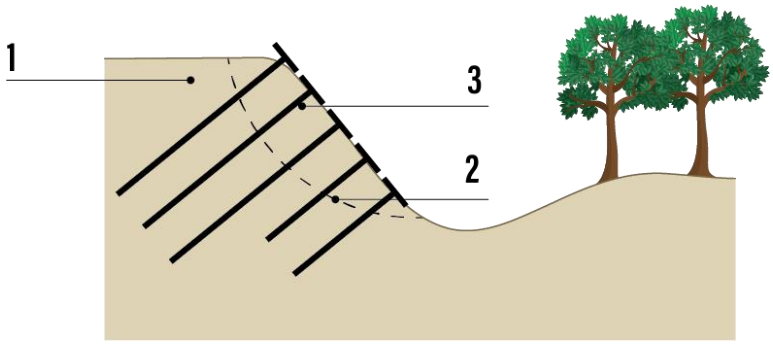

Figure 1. A cross-section through an unstable slope (1). A potential curved slip surface (2) is prevented from sliding by steel bar ground anchors (3) drilled and concreted into the slope.

Surprisingly, a serious earthquake-induced problem can lurk under even the soil of flat sites. This is especially the case where sites are underlain by loose sand under the water table. Earthquake shaking mixes the sand and water into a liquid slurry. Hence the term 'liquefaction'. Buildings founded on this now fluid material sink into it. They tilt, or even completely fall (Figure 2). Search the internet for "buildings liquefaction" to see many images. In extreme cases, such as during the 2018 Palu Indonesia earthquake, many houses were swept away and disappeared into soil that suddenly turned to mud.

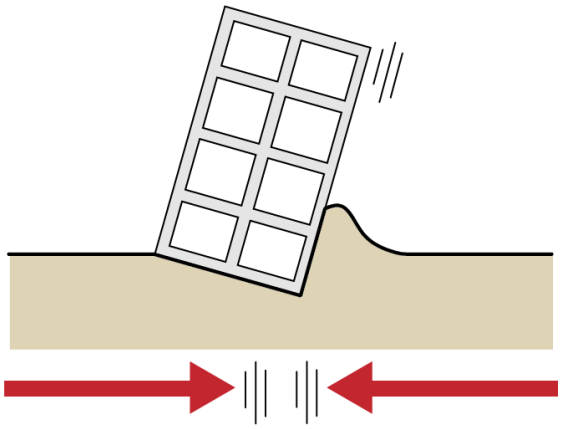

Figure 2. Ground shaking causes some soils to lose strength and liquefy, leading to the building tilting.

These potential hazards involving soils and earthquakes are a reminder for the need of pre-design and construction soil investigations. Soil tests are recommended. Simple tests for small buildings, but more extensive ones for larger projects. Civil engineers require results from these tests to be confident that the soil is capable of supporting the building's weight. Testing usually means drilling below the ground surface to ascertain the types of soils present (Figure 3). Samples are often taken which then may be tested in a laboratory. Especially for larger buildings, clients should engage a geotechnical engineer to arrange for tests, to interpret results and recommend design criteria. For sites on slopes or prone to liquefaction, geotechnical engineers can suggest measures to overcome the potential problems that jeopardize building safety.

Figure 3. A drilling rig sampling soil to be tested in a laboratory.

It is very important for building owners to undertake appropriate soil investigations during the design phase and before construction. This is particularly important for areas with soft soils.

About this article series:

This is a series of articles about earthquakes, their effects on buildings, and how to ensure that buildings are safe against earthquakes. They are intended for potential owners of new houses and larger buildings and others involved in the building industry. The articles are written by Andrew Charleson and colleagues from the World Housing Encyclopedia (http://www.world-housing.net/) which is sponsored by the Earthquake Engineering Research Institute (https://www.eeri.org/) and the International Association of Earthquake Engineering (http://www.iaee.or.jp/).

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