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COMMUNITIES: PRIVATE PRACTICE

Ten Things You Need to Know About Seismic Engineering

BY JOE FARRÉ, P.E.

In 2010, the world witnessed some of the largest and most devastating earthquakes in recent history. The resulting impacts to affected communities have inspired many engineers to refresh their knowledge of the basic seismic engineering principles. Mastering these 10 simple concepts will allow you to design seismically resistant structures that perform well under seismic loading.

1. **Earthquakes Create Strong Ground Motion**
   Earthquakes are characterized by strong ground motion beneath the earth's surface. This motion is caused by transmission of seismic waves through the soil particles. This ground motion can be caused by natural phenomena such as plate tectonics, volcanic activity, or heavy ground impact activities such as underground explosions or tall building demolition.

2. **Seismic Energy Travels as Waves**
   Seismic waves travel through the earth's core and surface soils as body waves and surface waves. Body waves transmit energy through the earth's core and surface materials as both high frequency P-waves and low frequency S-waves. The S-wave is a side-to-side shear wave. Body waves are responsible for the transmission of the earthquake's energy from deep within the core materials. Surface waves travel both vertically and laterally through the earth's crust, much like a wave moves across the ocean. Surface wave forms are mostly responsible for structural damage.

3. **Two Fault Types Classify Ground Movement**
   A dip-slip fault describes two fault surfaces that move vertically relative to each. A strike-slip fault describes two fault surfaces that move laterally relative to one another. Dip-slip faults can cause tidal waves or tsunamis while strike-slip faults do not.

4. **Beware of Soft Soils**
   Seismic waves that travel as low-amplitude, high-frequency waves through dense materials will transition to high-amplitude, low-frequency waves when they experience soft soils. This phenomenon is demonstrated by striking a bowl full of dense material, such as lead. When the energy hits the dense material, indiscernible surface waves are formed and the resulting energy travels through the dense material as a high-frequency, low-amplitude wave. The same strike on a bowl of water will generate a high-amplitude surface wave that can be clearly seen on the surface of the water.

5. **Avoid Getting Back Into the Swing of Things**
   Every structure has a natural period of vibration, or frequency at which the structure resonates. Seismic waves also vibrate at different frequencies, depending on soils and site conditions. A structural system will gain energy with each cycle of the seismic wave if the structure and the earthquake are in phase (i.e., the same frequency of vibration). This condition, also referred to as resonance, is analogous to a parent pushing a child on a swing. If the parent pushes too early or too late, the child loses energy and will not swing as high. However, if the parent times her push in perfect sequence with the fall of the swing, she creates a resonant effect that allows the height of the swing to grow. Resonance threatens structures.

6. **Stay Regular**
   Regular structures generally exhibit good performance under seismic events. Irregular structures can produce discontinuities in the force-resisting system and should be carefully designed. Heavy, irregular structures can produce significant seismic forces that may be difficult to resist.

7. **Be Flexible**
   Ductility is a term that describes a material's ability to withstand repeated cycles of inelastic deformations (yielding) with minimal loss of strength or load carrying capacity. A willow sapling that bends and rebounds during a wind storm exhibits ductile behavior while a rigid oak tree in the same storm is likely to topple. The key to good seismic design is to focus on ductility and to develop structures that possess the ability to dissipate energy through inelastic deformation.

8. **Don't Break The Code**
   Building code compliance can significantly impact the level of damage experienced during a seismic event. This is illustrated by the disparate amount of devastation experienced this year by the residents of Haiti and Chile. The comparatively superior performance of the structures in Chile clearly exhibited the benefits of improved seismic design and construction methods.

9. **Keep It Simple**
Designing with ductile materials and proper seismic detailing will produce earthquake-resistant structures. Utilizing ductile, well-detailed structural systems that are on good soils and have solid foundations can reduce the seismic forces imparted onto the structure.

10. **Match, Don't Mix**
Flexible structures should implement flexible retrofit measures, and rigid structures should utilize rigid retrofit measures. Incompatible retrofit schemes can render the measures useless or ineffective.

Joe Farré, P.E., is founder and president of Sigma Engineering Solutions Inc.(www.sigmanv.com), a structural and transportation engineering consulting firm with locations in Las Vegas and Roseville, California. He can be contacted at jfarre@sigmanv.com.

CONTACT

Questions? Want to send a letter to the editor? Contact
pemagazine@nspe.org