Site-Specific Geotechnical Earthquake Engineering Issues in the Central and Eastern U.S.

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Earthquake Engineering Issues in the CEUS

- Unique geologic features

- Fall line (Columbia)
- Coast line (Charleston)

- “Soft rock” sediments
- B-C Classification

- Hard Rock

- 160 km

- ~1 km
Earthquake Engineering Issues in the CEUS

- Unique geologic features in the CEUS. IBC maps developed for generic geologic conditions
  - High shear wave velocity rock (~2500 m/s) very close to surface, overlain by soil sediments (~250 m/s), resulting in high impedance contrasts (i.e. Columbia)
  - Deep sediment stack (B-C boundary mat'l) resulting in amplification of long period motions (i.e. Charleston)
- Uncertainty in characterizing the adsorption in the crustal rock (Q) and damping of the deep sediments.
- Lack of recordings. Challenges in finding candidate motions for site response analyses. Issues with selecting candidate motions from the Western U.S.
Columbia – Effect of High Impedance Contrast

Generic USGS

Columbia, SC

Assumed profile for CEUS 1996 National Hazard Maps

Shear Wave Velocity, $V_s$ (m/s)

Soil

Transition

Hard Rock

Site response

Deconvolute

Depth, D (m)

VirginTech
Computed Site Amplification Factors

Spectral Amplification Ratio
Ratio of the response spectra – Ground surface to base rock
(normalized to Site Class B)
Computed Site Amplification Factors

Spectral Amplification Ratio
Ratio of the response spectra – Ground surface to base rock (normalized to Site Class B)
Comparison with IBC Spectra

- Significant amplification, beyond the code, especially at site-class C.
- The reason for higher amplification at “C” sites has to do with the match between frequency content of the rock motion and the site period at these sites.
Typically up to 20 meters of soft/loose soils at the top ($V_s < 200 \text{ m/s}$). Underlain by Tertiary deposits ($V_s \sim 700 \text{ m/s}$) about 800 meters thick.

- Code highly conservative at $T < 0.4 \text{ sec.}$
- Potential concern at longer periods, especially $T > 3 \text{ seconds}$
  ($T_{\text{fund sediment stack}} \sim 4-5 \text{ seconds}$)
- Limitation of using synthetic motions
- Lacking the benefit of multiple recordings to cover the "natural" variability between different events, regional conditions
Summary

- Uncertainty a big issue in ground motion estimates in the Central and Eastern U.S.
- Lack of recordings.
- Deep sediment stack acts as a filter and deamplifies the short period motions. Code may be unconservative at long periods (T > 3 seconds)
- High impedance contrast can cause “unusual” amplification of ground motions. C sites may possibly amplify as E sites.
- Site classification based on top 30 meters can be misleading in these areas.
Typical Questions & Decisions

- How many EQ input motions to use? What type of motions? Just synthetics?
- Sensitivity of results to inputs? Is the answer controlled by input motions? site response? soil behavior? structural characteristics?
- How should final design spectrum be established from site-specific analysis results?
- What confidence level should be associated with the design spectrum? Median? +1 Std. Dev.?; that is, how do we systematically judge the results?