Ground Motions for Performance-Based Earthquake Engineering:
Selection of Ground Motions for Nonlinear Analysis

State-of-the-practice on time series selection and scaling for nonlinear analysis

Marshall Lew, Ph.D., G.E.
MACTEC Engineering and Consulting, Inc.
Los Angeles, California

Selection of Ground Motions for design is not new

- – Seismic Base Isolation (1985)
- – Energy Dissipation Systems
- – New Technologies

Selection of Ground Motions for design

– Find "Seed" ground motions from events with similar site conditions and geology, style of faulting, distance, and magnitude

Despite the proliferation of new ground motion time histories from recent events, still lacking sufficient time histories for large magnitude events, near-source sites, and soft & hard rock sites.

Selection of Ground Motions for design

- How "pure" do you want your ground motions?

  Some argue for using the existing ground motions in an unmodified form, only scaling arithmetically (up or down) and not modifying the frequency content.

  Problems arise in scaling to the design response spectrum where one point meets the design spectrum and every other point exceeds or greatly exceeds the spectrum.

Selection of Ground Motions for design

- How "pure" do you want your ground motions?

  If you modify the ground motions to match the design spectrum, how do you do it?

  - *Design spectrum is not any indication of reality*
  - *Design spectra with longer recurrence intervals include much uncertainty*
  - *Matching in the frequency domain may add more energy than in actual earthquake ground motions*

Selection of Ground Motions for design

- How "pure" do you want your ground motions?

  If you modify the ground motions to match the design spectrum, how do you do it?

  - *Matching in the time domain by adding sine-packets (so-called Abrahamson method)*

  - *Loose or close matching?*

Selection of Ground Motions for design

– How many time histories are enough to characterize the ground motions?

- *Building Codes either allow for maximum of 3 or average of 7 sets.*

- *Do these ground motions represent all of the possible types of events that could reasonably happen (e.g., near-source and distant events)?*

Selection of Ground Motions for design

- Do the ground motions need to include near-source directivity effects?
  - *Not currently required by any building codes*
  - *But any reasonable, knowledgeable peer reviewer would ask the question*

- What about basin or edge-of-basin effects?

Selection of Ground Motions for design

Always challenging

Sometimes requiring compromise

Not always feeling satisfied