Ground Motion Selection and Scaling
for the analysis of the tall building case studies

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Challenges

- Significance of several modes of vibration in response of the building.
- Similar ground motions for all structures.
- Five hazard levels needs to be looked at.
- A large number of motions are required (we used 15) to have a reasonable estimate of the dispersion in EDP.
Disagg. for 2% / 50, T = 1.0 sec.
Disagg. for 2% / 50, $T = 5.0$ sec.
Site Hazard Characterization

In low probability hazard levels:

- For long periods, hazard is dominated by two events. M = 6.6 & R = 5km (ε = 1.5), and M = 8 & R = 60km (ε = 2.5).

- For short periods, hazard is dominated by single event. M = 6.6 & R = 5km (ε = 1.5).

In high probability hazard levels:

- Domination of a single or two events is not significant. Epsilon ranges from -2 to 2 with a mean value of zero.
Record Selection and Scaling Process

Selection:

- Used a subset of NGA database (no aftershocks & etc.)
- Only two recordings from any single event was selected
- No restriction on Magnitude
- $R_{\text{min}}$ & $R_{\text{max}}$ at 0.0 and 100.0 Km
- Min and Max shear wave velocity = 180.0 and 1200.0 m/s
- Low pass filter cutoff frequency of the selected motions are less than 0.1
Record Selection and Scaling Process

Scaling:

- Maximum acceptable scale factor = 5.0
- The scale factor, by which the smallest weighted error between the target spectrum and the geometric mean spectrum of a single recording is acquired, is computed.
- Records are matched between $T_{\text{min}}$ & $T_{\text{max}}$ at 0.5 & 10.0 sec.
  - Largest $T = 6.47$ sec. (Bldg. IIIB) $\rightarrow$ $6.47 \times 1.5 = 9.7$ sec.
  - Smallest $T = 4.28$ sec. (Bldg IIIB) $\rightarrow$ $4.28 \times 0.2 = 0.86$ sec.
Record Selection and Scaling Process

Scaling:

- Maximum acceptable scale factor = 5.0
- The scale factor, by which the smallest weighted error between the target spectrum and the geometric mean spectrum of a single recording is acquired, is computed.
- Records are matched between $T_{\text{min}}$ & $T_{\text{max}}$ at 0.5 & 10.0 sec.
Record Selection and Scaling Process

Reduction in Sampling Frequency:

- Reduced the ground motion time step from its original to 0.04 (25 samples per second = 25Hz)
- Eliminated the effect of aliasing by filtering original ground motions beyond the Nyquist frequency (12.5 Hz)
Record Selection and Scaling Process

A typical case of small difference

A typical case of larger difference

PBD, Roof displacement, N-S direction

Original ground motion

Filtered and down-sampled ground motion
GM set

OVE

MCE

DBE

SLE43

SLE25

MAXIMUM IDR

N-S, dt=original

N-S, dt=.04

difference

median

%16th and %84th

Individual earthquake

N-S

E-W
Response Spectra SLE25 (25 year)
Response Spectra SLE43 (43 year)
Response Spectra DBE (475 year)
Response Spectra MCE (2475 year)
Response Spectra OVE (4975 year)

Matched Spectra for TBI (OVE, 3 & 0.1, 7 & 0.6)

7 unscaled pairs are from simulated motions (URS/SCEC)
Response Spectra OVE (4975 year)
Response Spectra OVE (4975 year)
Summary

- 5 sets of 15 ground motion records representing hazard levels from 25 year return period to 5000 year return period are selected for the purpose of los estimation.

- Ground motion are matched to the target spectrum for the location of the buildings. (meets code requirements, and similar to procedures used by engineering seismologists)

- Same ground motions are used for all buildings.

- For the very low probability hazard level (OVE) a combination of recorded and simulated motions is used