PROCESSING OF THE PEER NGA-WEST 2 DATA SET

November 29, 2011

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PEER Processing: Objectives

Strong motion data processing has two major objectives to make the data useful for engineering analysis:

(1) correction for the response of the strong motion instrument itself, and
(2) reduction of random noise in the recorded signals.
PEER Processing: Differences

• The processing of the strong motion records in the PEER database is in general different than the processing done by the agency that collected the data.

• Although the processed records may be different, the differences should be small within the frequency pass band common to both processing procedures.
PEER Processing: Key Steps

• Data Selection:
  Analog: Volume 1 (unevenly sampled in time)
  Digital: Volume 1 (highest sample rate)
  Volume 2: used only if necessary

• Tapering (e.g. 5% front and back) Care needed especially with analog verticals
Key Steps: Analog Recordings (e.g. SMA)
Hard Rock sites

• Interpolate unevenly sampled data to 600 samples per second (Nyquist 300 Hz)

• Low-pass anti-alias filter (50 Hz)

• Decimate to 200 samples per second (100 Hz (decimation to 50 sps (25 Hz) in Vol 2)
Key Steps: Noise Analysis

- Noise Analysis: Fourier amplitude spectrum (instead of response spectrum)
  - High frequency: flattening or increase due to noise
  - Long period: departure from $1/\omega^{**2}$
- Filtering: component by component (instead of using the same filter for all components, usually vertical controls bandwidth), both acausal and causal Butterworth filters
PEER Processing: Key Steps

• Iterative process between filtering and time domain to eliminate unphysical velocity and displacement time histories

• Compatible waveforms (acceleration, velocity, displacement) and spectra

• Maintain high sample rate (do not decimate to (e.g. 50 samples/sec (Volume 2) to maintain peak values)
HIGH FREQUENCIES AT HARD ROCK SITES

• Hard rock sites require a bandwidth from several seconds to over 30 Hz (for \( M > 4.5 \)). Several strong motion data sets have been reprocessed and included in the PEER Strong Motion Database.
High Frequency

• PEER processing has increased the average horizontal 5% damped response spectra at various hard rock sites at high frequencies

• Four examples
CERRO PRIETO 02/06/87
Magnitude 5.4 STA CERRO PRIETO

COALINGA AFTERSHOCK
Magnitude 5.1 SKUNK HOLLOW
OROVILLE AFTERSHOCK K
Magnitude 4.9 STATION 6

SAN FERNANDO 02/09/71
Magnitude 6.4 PACOIMA DAM
High Frequency

- PEER processing has increased the average horizontal 5% damped response spectra at these hard rock sites at high frequencies.

Reasons:
- Horizontal component filter selection, independent of vertical
- Higher sample rate maintained
## High Frequency: 1987 Cerro Prieto

<table>
<thead>
<tr>
<th>Volume 1</th>
<th>Volume 2</th>
<th>PEER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.450 g</td>
<td>1.148 g</td>
<td>1.313 g</td>
</tr>
<tr>
<td>0.925 g</td>
<td>0.868 g</td>
<td>0.857 g</td>
</tr>
</tbody>
</table>

### Sample Rate and Filter information

- **Volume 1**: 200 sps, None
- **Volume 2**: 50 sps, 23-25 Hz
- **PEER**: 200 sps, 50 Hz
PEER Processing: Example

- Acausal filters with pads removed (Standard PEER for NGA-W2)
- Acausal filters with pads retained
- Causal filters
LOMA PRIETA, AGNEWS STATE HOSPITAL, 090, ACAUSAL: PADS REMOV
LOMA PRIETA, AGNEWS STATE HOSPITAL, 090, ACAUSAL: PADS KEPT
LOMA PRIETA, AGNEWS STATE HOSPITAL, 090, CAUSAL
COMPARISON OF RESPONSE SPECTRA
LÖMAP : AGW: 090

LEGEND
- - 5 %, DYNAMIC (CAUSAL Filtering IN THE PEER DATA BASE), HP=12.05 sec
- - - - 5 %, DYNAMIC (ACOUSAŁ Filtering, STANDARD, PADS REMOVED), HP=12.05 sec
- - - - - 5 %, DYNAMIC (ACOUSAŁ Filtering, ZEROS AT END, PADS KEPT), HP=12.05 sec
NGA-W2 Data: Additional data from NGA-W1 earthquakes

- SMART-1 data at all sites
- USC analog data from Whittier Narrows aftershock (SMA-1)
- Borrego Mtn, North Palm Springs, Cape Mendocino, Landers, Hector Mine, Denali, Yountville, Northridge and Chi-Chi aftershocks,
- Various Italian earthquakes
NGA-W2: New Earthquakes
WUS

- San Simeon, CA (67)
- Parkfield (90)
- El Mayor-Cucapah, Mexico (237)
- Joshua Tree, CA (5)
- Mohawk Valley, Portola, NV (5)
NGA-W2: New Earthquakes
Asia

- Wenchuan, China (263)
- Wenchuan aftershocks (1063)
- Chuetsu, Japan (616)
- Iwate, Japan (367)
- Niigata, Japan (530)
- Tottori, Japan (414)
NGA-W2: New Earthquakes
New Zealand, Iran and Europe

- Darfield, New Zealand (114)
- Christchurch, New Zealand (104)
- Bam, Iran (24)
- L’Aquila, Italy and 2 aftershocks (117)
- Various Italian earthquakes (200)
- Montenegro, Yugoslavia (11)
PEER Processing: References

• Abrahamson and Silva, (1997) Seismological Research Letters
• Chiou, Darragh, Gregor and Silva, (2008) Earthquake Spectra
• http://peer.berkeley.edu/smcat/process.html
PEER Processing: Comparisons


• Boore, Azari and Akkar, ”Using pad-striped acausally filtered strong-motion data” (under review)

• Grazier and Bagchi, “Effects of low-pass filtering and re-sampling on spectra and peak ground acceleration in strong-motion records” (under review)
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• “There is no inconsistency here, for the PSAs at oscillator frequencies near 100 Hz are being determined at lower frequencies in the input record…” Douglas and Boore (2011)
PEER Processing Comment

• “We come to the important conclusion that any biases and distortions are small for the vast majority of the records, and thus data from ITACA and PEER NGA can be used with confidence that the post-processing has not affected the bulk of the results.” (Boore, Azari and Akkar, in review)