NGA-West2 Research Program

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November 15, 2012, UC Berkeley
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NGA-West1

NGA-West1 (Original NGA Project)

- PEER compiled a very comprehensive database of ground motions recorded in shallow crustal earthquakes in active tectonic regions
- Numerous supporting research studies were also carried out
- In 2008, Next Generation Attenuation (NGA) ground motion prediction equations (GMPEs) were developed
- USGS adopted the NGA-West1 GMPEs for the US National Seismic Hazard Maps
- NGA-West2 is a follow-up of NGA-West1
Supports of the sponsors are appreciated
NGA-West2 Sub-Projects
Update worldwide database
Update worldwide database

![Graph showing the relationship between Moment Magnitude and Closest Distance to Rupture (km). The graph compares the Original PEER Database (1997) with the NGA-West1 added data (2003).]
Update worldwide database

From NGA-West1 to NGA-West2 the size of database was increased by a factor of 5.5.

NGA-West2 database includes over 19,000 three-component recordings... over 57,000 records.
Moderate-to-large magnitude worldwide database
Moderate-to-large magnitude worldwide database
### Examples of data added to NGA-West2 database

<table>
<thead>
<tr>
<th>Earthquake Name*</th>
<th>Year</th>
<th>M</th>
<th>N Rec</th>
<th>Rrup Range (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tottori, Japan</td>
<td>2000</td>
<td>6.61</td>
<td>414</td>
<td>1-333</td>
</tr>
<tr>
<td>Niigata, Japan</td>
<td>2004</td>
<td>6.63</td>
<td>530</td>
<td>8-300</td>
</tr>
<tr>
<td>Chuetsu-oki, Japan</td>
<td>2007</td>
<td>6.8</td>
<td>616</td>
<td>10-300</td>
</tr>
<tr>
<td>Iwate, Japan</td>
<td>2008</td>
<td>6.9</td>
<td>367</td>
<td>5-280</td>
</tr>
<tr>
<td>El Mayor-Cucapah, CA</td>
<td>2010</td>
<td>7.2</td>
<td>238</td>
<td>11-240</td>
</tr>
<tr>
<td>Darfield, New Zealand</td>
<td>2010</td>
<td>7</td>
<td>114</td>
<td>1-540</td>
</tr>
<tr>
<td>Christchurch, New Zealand</td>
<td>2011</td>
<td>6.1</td>
<td>104</td>
<td>2-440</td>
</tr>
<tr>
<td>Wenchuan, China</td>
<td>2008</td>
<td>7.9</td>
<td>263</td>
<td>1-1500</td>
</tr>
<tr>
<td>L'Aquila, Italy</td>
<td>2009</td>
<td>6.3</td>
<td>48</td>
<td>5-230</td>
</tr>
</tbody>
</table>

*subset of added events
Comparison of NGA-West1 & NGA-West2 databases

<table>
<thead>
<tr>
<th>Data Set</th>
<th># EQs</th>
<th># Rec</th>
<th>Sa Type</th>
<th>Damping</th>
<th>Periods (sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NGA-West1</td>
<td>173</td>
<td>3,551</td>
<td>AR, GMRotI50</td>
<td>5%</td>
<td>0.01 - 10</td>
</tr>
<tr>
<td>NGA-West2</td>
<td>610</td>
<td>19,400</td>
<td>AR, RotDnn</td>
<td>0.5-30%</td>
<td>0.01 - 20</td>
</tr>
</tbody>
</table>

AR = As-recorded
RotDnn definition

- At each period, rotate horiz. components,
- Rot$D_{50}$ = 50 percentile,
- Rot$D_{100}$ = max,
- Rot$D_{00}$ = min

Motivation: Users can use the maximum rotated motion
Why did we add small magnitude data?

Motivation:

- NGA-West1 models over-predicted motions for small magnitude
- In the future, we can analyze multiple events recorded at same site to characterize the site variability (single-station Sigma)
- In the regions that have mainly small magnitude data, they can compare NGA with their data
Magnitude scaling at small magnitude

PGA

SA(1.0s)
Update NGA GMPEs for horizontal motion

- Using the latest database
- Using supporting research on:
  - Directivity of ground motion
  - HW/FW model using simulations data
  - Update of nonlinear soil response
  - New classification of “main shock” vs “aftershocks”
  - ...

Develop GMPEs for vertical component

- NGA-West1 models predicted only horizontal ground motions
- Recorded data have shown that vertical ground motion can be large at the sites close to active faults

![Graph showing V/H ratio vs. period for different source-to-site distances.]

Do not use 2/3 to scale horizontal motion to get vertical
Damping scaling of response spectra

- Scale GMPEs for damping other than 5%:
  - **0.5% to 30%**

- Damping scaling model is final; PEER report already published
Directivity

- NGA-West1 models did not explicitly include directivity of ground motion
- Five directivity models have been developed
  - Wide-band and narrow-band models
- Effects of directivity will be included in NGA-West2 GMPEs
Directionality (Polarization)

- NGA models are for “geometric mean” horizontal components
- Develop max and min rotated spectra, as a function of mag, distance,…
- Examine relationship of max/min spectra with RotD50 (50 percentile) spectra

Ref: Boore (2010)
Epistemic uncertainty model

- Develop epistemic uncertainty model for NGA-West2
- Will need final GMPEs
- Will be carried out by January 31, 2013
Site Response

- NGA-West1 site amplification factors are inconsistent with NEHRP site amplification factors
- Goal: To make NEHRP and NGA site amplifications consistent
  - Propose changes in NEHRP factors
- This is both scientific and consensus-building task
NGA-West2 Status

- Some tasks have already been completed
  - Databases, damping scaling, directivity, directionality, site response
  - Draft final reports are being reviewed internally and externally

- Draft of GMPEs for horizontal components are ready for review to obtain:
  - Feedback from the USGS National Hazard Maps, internal and external reviewers
  - Feedback from the community (this workshop)
Draft final reports on horizontal and vertical GMPEs and epistemic uncertainty will be sent to the sponsors and reviewers by January 31, 2012.


Finalize all reports for public release: April 15, 2013.

Flatfiles of database used by the NGA-West2 GMPE developers will be posted at PEER web site.
Purpose of Today Workshop

- To inform the community about our preliminary findings and models
- Obtain feedback
Many people have been involved in NGA-West2

- **Technical Coordination Committee:**
  - Abrahamson, Bozorgnia, Campbell

- **External reviewers and oversight committee:**
  - Chris Wills, Mark Petersen, John Anderson, Roger Borcherdt, Silvia Mazzoni, Farzad Naeim

- **Funding agencies representatives:**
  - Badie Rowshandel & Tom Shantz
Many people have been involved in NGA-West2 (cont’d)

- **Database**: Ancheta, Darragh, Silva, Chiou, Stewart, Seyhan, Graves, Wooddell, Katke, Boore, Kishida, + NGA developers
- **GMPEs**: Abrahamson, Silva, Campbell, Bozorgnia, Idriss, Abrahamson, Campbell, Silva & GMPE developers
- **Damping**: Rezaeian, Bozorgnia, Idriss, Abrahamson, Campbell, Silva & GMPE developers
- **Vertical**: GMPE developers
- **Directivity**: Spudich, Chiou, Baker, Shahi, Rowshandel, Watson-Lamprey & GMPE developers
- **Directionality**: Baker, Shahi, & directivity group
- **Epistemic Uncertainty**: Youngs, Al Atik
- **Site Response**: Stewart, Seyhan, & working group

Putting together pieces of a complicated puzzle through a large coordinated multidisciplinary Team Work
Many people have been involved in NGA-West2 (cont’d)

- **Database**: Ancheta, Darragh, Silva, Chiou, Stewart, Seyhan, Graves, Wooddell, Katke, Boore, Kishida, + NGA developers

- **GMPEs**: Abrahamson, Silva, Campbell, Bozorgnia, Chiou, Youngs, Boore, Atkinson, Stewart, Seyhan, Idriss

- **Damping**: Rezaeian, Bozorgnia, Idriss, Abrahamson, Campbell, Silva & GMPE developers

- **Vertical**: GMPE developers

- **Directivity**: Spudich, Chiou, Baker, Shahi, Rowshand, Watson-Lamprey & GMPE developers

- **Directionality**: Baker, Shahi, & directivity group

- **Epistemic Uncertainty**: Youngs, Al Atik

- **Site Response**: Stewart, Seyhan, & working group

**NGA Participants**: Thank you for your hard work, dedication, and world-class contributions.
THANK YOU for YOUR ATTENTION!
Agenda

- 8:30 – 9:00  **Overview** of NGA-West2 Project (**Yousef Bozorgnia**)
- 9:00 - 9:30  NGA-West2 **Database** (**Tim Ancheta**)
- 9:30 - 10:15  **Site** Database & NEHRP Site Factors (**Jon Stewart**)

10:15 - 10:30  Break

10:30 – 11:00  **Damping** Scaling Models (**Sanaz Rezaeian**)
- 11:00 -11:45  **Directivity** Models (**Paul Spudich**)
- 11:45 - 12:15  **Directionality** of Ground Motion (**Jack Baker**)

12:15 - 1:00  Lunch
- 1:00 - 1:15  **Nonlinear Site Response** Model (**Ronnie Kamai**)
- 1:15 - 1:30  New **hanging Wall** Model (**Jennifer Donahue**)
- 1:30 – 1:45  Classification of “**Main Shock**” / “**Aftershock**” (**Katie Wooddell**)
- 1:45 – 2:15  **Abrahamson-Silva** Updated GMPE (**Norm Abrahamson**)
- 2:15 - 2:45  Boore-Atkinson-Seyhan-Stewart GMPE (**Boore, Stewart**)
- 2:45 - 3:15  **Campbell-Bozorgnia** Updated GMPE (**Ken Campbell**)

3:15 - 3:30  Break

3:30 – 4:00  **Chiou-Youngs** Updated GMPE (**Brian Chiou**)
- 4:00 - 4:30  **Idriss** Updated GMPE (**I.M. Idriss**)
- 4:30 - 5:00  **Comparison** of GMPEs (**Norm Abrahamson/Nick Gregor**)
- 5:00 - 5:30  Final Discussions and Concluding Remarks (**Yousef Bozorgnia, All**)
- 5:30  Adjourn