Characterization of Ground Motion Hazard

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PEER Summative Meeting - June 13, 2007
Numerous Research Projects on Characterization of Ground Motion Hazard

- Attenuation models and related projects
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- Ground motion selection & modification for nonlinear analysis

NSF-PEER Summative Meeting
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- Ground motion selection & modification for nonlinear analysis
- Investigation of various IMs

![Inelastic Spectra](image)
Numerous Research Projects on Characterization of Ground Motion Hazard

- Attenuation models and related projects
- Ground motion selection & modification for nonlinear analysis
- Investigation of various IMs
- Input motion for tall buildings with large embedded structures
Next Generation Attenuation (NGA) Models
**Next Generation “Attenuation” (NGA) Is a Multidisciplinary “Program”**

- Coordinated by PEER over the last four years
- Bringing together: *geologists, seismologists, geotechnical engineers, structural engineers,* and *users* of ground motion models
- And Researchers, practitioners
PEER Compiled One of the Largest Uniformly-Processed Strong-Motion Databases in the World

- 173 worldwide earthquakes
- > 10,500 uniformly processed records

Previous Data  New Data
PEER Strong-Motion Database

There are more than 100 variables describing source/path/site conditions of a record:

- 6 types of distance measures
- 4 site classification schemes
- Estimated $V_{s30}$ for most of recording sites
- HW/FW classes

The database is fully available to the public
NGA Model Developer Teams

- Abrahamson & Silva (updating their 1997 model)
- Boore & Atkinson (updating Boore et al., 1997 model)
- Campbell & Bozorgnia (updating their 1997, 2003 models)
- Chiou & Youngs (updating Sadigh et al., 1997 model)
- Idriss (updating his 1993 & 1996 models)

All model developers started with a common database
NGA Attenuation Models

Ground motion parameters:
- Horizontal components
- PGA, PGV, PGD
- Pseudo spectral acceleration at 5% damping
  - Period: 0 - 10 sec

Magnitude range:
- 5.0 - 8.0+

Distance range:
- 0 - 200 km

Fault Mechanism:
- Strike-Slip
- Reverse
- Normal

Site Effects:
- $V_{s30}$
NGA Models Were Constrained by Simulation

- To fill the gaps in data
- Simulations of 3-D basin and 1-D rock motions
  - To model amplification due to sediment-depth
  - To constrain attenuation models
- Nonlinear soil response analysis
  - Amplification factors for different soil profiles subjected to a wide range of input motions
Example Result: C&B NGA Predicted Acceleration Spectra
Strike Slip, $M = 7.0$, $V_{S30} = 760$ m/s
Behavior at Long Periods
C&B NGA Predicted Spectral Displacement
Strike Slip, $R_{RUP} = 10$ km, $V_{S30} = 760$ m/s
Examples of Comparison of NGA Models
Campbell & Bozorgnia (C&B) NGA vs. C&B 2003
Strike-Slip Fault, NEHRP B-C

PGA, Strike Slip, $V_{S30}=760$

SA(1.0s), Strike Slip, $V_{S30}=760$

Closest Distance to Rupture (km)

Moment Magnitude

Acceleration (g)

$R_{RUP}=0.1$

$M = 8.0$

Campbell & Bozorgnia (2003)
Campbell & Bozorgnia (NGA May 06)
$S_a(T=1.0s) \text{ – Strike-Slip, M 7.5, NEHRP B-C}$

Magnitude = 7.5 -- $T = 1$ sec -- Strike Slip

- Abrahamson & Silva ($V_{s30} = 760$ m/s)
- Boore & Atkinson ($V_{s30} = 760$ m/s)
- Campbell & Bozorgnia ($V_{s30} = 760$ m/s)
- Chiou & Youngs ($V_{s30} = 760$ m/s)
- Idriss [$V_{s30} = 450 -- 900$ m/s]
NGA &
US National Seismic Hazard Maps
Impact of NGA Models on Seismic Design

- USGS has extensively reviewed NGA, and is adopting the NGA models for the US National Seismic Hazard Maps.
- Design spectra based on either deterministic or probabilistic approach will be affected by NGA models.
Using same set of fault sources as 2002 maps; Subduction zone and deep earthquakes are not included

Rock site condition

Period=0.2 sec Spectral Acceleration 2% P.E. in 50 years

Ratio of New/ Old:
Using 3 NGA relations
Versus:
2002 Hazard Maps
Abrahamson and Silva (1997), Sadigh et al. (1997), Boore et al. (1997), Campbell and Bozorgnia (2003), Spudich et al. (1999) for extensional areas

Using same set of fault sources as 2002 maps; Subduction zone and deep earthquakes are not included

Preliminary Map
Period=1.0 sec Spectral Acceleration
2% P.E. in 50 years

Ratio of New/ Old:
Using 3 NGA relations
Versus:
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Preliminary Map
Reasons...

- “Some of the decrease of 1 sec $S_a$ from the 2002 maps is caused by:
  - Difference in the Vs30 assigned for “rock” sites in the 2002 maps and the average $V_{s30}$ for rock sites reported in NGA (shouldn’t be a factor in the Campbell-Bozorgnia and Boore-Atkinson NGA relations)”

- “Most of the decrease is from having additional data from moderate and large earthquakes and improved functional forms to fit the data”
NGA Reports & Papers

- Draft final reports are available at PEER web site
- Including computer files of the models
- PEER reports are being printed
- Journal papers will be published in special issue of EERI Spectra, March 2008
NGA Models Are More Robust Than Old Models Because…

- Quantity and quality of data
- Amount of time the developers spent on models
- Interactions among model developers
- Number of independent variables
- Availability of supporting ground motion simulations
- Public participation via workshops and conferences
- Formal peer review commissioned by USGS
Finally...It would have been much more difficult to accomplish NGA without a framework of a national earthquake engineering center.

Example: For NGA, PEER coordinated efforts, and has had research contracts with:

- USGS (different researchers)
- California Geological Survey
- SCEC (various contracts)
- Various universities
- Several firms and practitioners
Special Thanks To: