Project ‘17
Development of Next-Generation Seismic Design Value Maps

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Project 17 Committee
Purpose

• For the past 20 years, the maps have been based on science, but tempered with engineering input
• As the science evolves, more substantive input is appropriate
• Provide coordination between Structural Engineers and USGS scientists to plan future development of national seismic design maps for incorporation in the 2020 NEHRP Provisions (and ASCE 7-22)
Some History

1970s

2016
ATC 3-06

- Introduced separate mapping of “short period” and “long period” motion
- Identified “Design Motion” as 475-year return period (10% - 50 year exceedance)
- Identified worst Zone 4 motions as
  - 0.4g pga
  - 1.0g short period response
  - 0.4g Sa(1 second)
Project '97

- Introduction of MCE and DE shaking
  - MCE defined as 2%/50 year motion with deterministic caps
  - DE defined as 2/3 of MCE motion, adjusted for site class effects
- Adoption of $S_{DS}$ and $S_{D1}$ as primary seismic design parameters
- Introduction of MCE spectral parameter contour maps
- New design procedure tailored to use of the MCE maps
- USGS web-based applet to provide design values
Project ‘07

• Adoption of:
  – NGA models
  – “Maximum Direction” component

• Development of Risk-Targeted Maximum Considered Earthquake Concept (MCE_R)
  – Risk category II structures should have not less than a 10% chance of collapse given MCE_R shaking
    • Probabilistic zones:
      Ground motion resulting in a 1%-50 year collapse probability (for Risk Category II structures)
    • Deterministic Zones:
      1-sigma attenuation on characteristic earthquake
ASCE 7-16

- Initially rejected 2014 USGS maps
- Adopted as a “last minute” change of mind
- General dissatisfaction with the lack of engineering input and the “pogo stick effect”
The Pogo Stick

![S1 over time 7 Cities graph](image)
Planning Phase (2015)
Committee Charge

• Assess existing issues related to the National Seismic Design Maps
  – Identify emerging technologies for consideration
  – Improvements in Science
  – Needs for Design

• Develop recommendations for Project 17, which like Projects 97 and 07 will set the stage for the next generation maps
Planning Phase Activities

• Introductory meeting
  – Developed issues for consideration
• Webinars / solicitation of public input
• Final meeting to prepare recommended program
• Publication of report recommending program
Identified Issues

• Procedural
  1. Timing for map publication
  2. Design Value Conveyance
  3. Precision v. Uncertainty
  4. Acceptable Collapse Risk
  5. Collapse Risk Definition
  6. Maximum Direction Component or Geomean
Identified Issues

- Mapped Parameters
  7. Multi-Period Spectral Values
  8. Duration
  9. Damping Levels
  10. Vertical Motion
Identified Issues

- Value Derivation
  11. Deterministic Parameter Derivation
  12. Basin Effects
  13. Use of 3-D Numerical Simulation in Seismic Hazard Models
Timing for Map Publication

• From 1997 through 2003, USGS updated the seismic design value maps on a 3-year cycle
  – Timed to allow adoption in successive IBC editions
  – Changes from map edition to edition were generally small

• Since 2003 USGS has gone to a 6-year cycle, coinciding with publication of ASCE-7
  – Changes to maps tend to be more pronounced
  – Little time is available for review and building consensus and acceptance of the new maps
Design Value Conveyance

1991
1 Map

2000
14 Maps

2005
20 Maps

SS S1 TL
Design Value Conveyance

2016

S_s

S_1

T_L

pga

32 Maps
Design Value Conveyance

• Maps for:
  – 0 sec, 0.2 sec, 0.5 sec, 1 sec, 2 sec, 2.5 sec, 3 sec, 9 sec, 10 sec.
  – $V_{s30}$: <200 m/s, 300 m/s, 400 m/s, 500 m/s, 1000 m/s, >2000 m/s
  – Damping .5%, 2.5%, 5%, 10%, 15%, 20%, 25%
Precision vs. Uncertainty

- Contours are in 0.05 g gradations
- Uncertainties are on the order of 0.6 or higher

$S_s$ Contours Middle U.S.
Acceptable Collapse Risk
Collapse Risk Definition

- FEMA P-695 suggested acceptable collapse risk of 10% given MCE motion
- ASCE 7-10 adopted this criterion and developed MCE\(_R\) with this basis
- Recent earthquakes do not support a collapse risk this high
Geomean v Max Direction Component

- FN – 0.25g
- FP – 0.40g
- X – 0.28g
- Y – 0.5g
- Geomean = 0.37g

X=0.28g, Y=0.5g, GM=0.37g
Multi Period Spectra

\[ S_{DS} = \frac{2}{3} x S_{MS} = \frac{2}{3} x F_a x S_t \]

\[ S_{DT} = \frac{2}{3} x S_{Mt} = \frac{2}{3} x F_v x S_t \]

\[ C_s = \frac{S_{DT}}{R/I_e} \quad T \leq T_s \]

\[ C_s = \frac{S_{DT}}{T(R/I_e)} \quad T_s < T \leq T_L \]

\[ S_s = \frac{S_{DS}}{T} \]

\[ S_1 = \frac{S_{DS}}{T_s} \]

\[ T_s \leq T \leq T_L \]

\[ C_s = \frac{S_{DS}}{T(R/I_e)} \]

\[ T_s < T \leq T_L \]

84th percentile response spectra of an M8.0, strike-slip, earthquake at R = 5 km for Site Class A (1,520 mps), B (760 mps - \( S_s = 1.84g \), \( S_1 = 0.77g \)), C (530 mps), D (260 mps) and E (130 mps) site conditions (2008 NGA relations).
Duration

Crustal record
duration ~ 25 seconds
Strong motion ~ 10 seconds

Subduction record
duration ~ 3-4 min
Strong motion ~ 1-1/2 min.
Damping Levels

$R_{rup} = 10 \text{ km}$

Predicted Median DSF vs Period, s for different damping levels (0.5%, 1%, 2%, 3%, 7%, 10%, 20%, 30%).
Vertical Shaking Parameters

\[ E_v = 0.2S_{DSD} \]
Deterministic Parameters

- **Deterministic Motion from Maximum Magnitude Event**
- **Major Fault**
- **Probabilistic Motion @2%-50 years**
- **150% of 1997 UBC Zone 4 no near field**

Distance
Basin Effects
3D Simulation
Last Men Standing

• Precision v. Uncertainty
  – How to bring stability to the process
  – How to represent ground motion parameters with Significant figures

• Acceptable Risk
  – Maintain Risk Adjustment
  – Calibrate to:
    • 2,500 yr -1%/50 year
    • 1,000 yr – 2% / 50 year

• Multi-point spectra
  – How to create
  – Design procedure
  – Applicabiltiy

• Deterministic Caps
Planned Effort

• 2 Years
  – 3 main committee meetings per year
  – 3 subcommittee meetings per year
  – Develop recommendations to:
    • USGS
    • PUC
Questions