GROUND MOTION MAPS
How To Obtain the Basic Values

This series of slides would not normally be used as is but rather to develop a Group Exercise that shows how to use the USGS website to retrieve certain ground motion data from the USGS website (see Slide 9 in this set).
Seismic Ground Motions

1. Determine basic values from maps for bedrock conditions
2. Classify soil conditions at site and determine site coefficients
4. Determine site-adjusted values
4. Take two-thirds for use in design
5. Construct design response spectrum
7. Site-specific studies permitted/required

This lesson focuses on the first step: getting the basic values from the maps. Subsequent lessons will cover the other steps.
Mapped Acceleration Parameters

• Two sets of maps; acceleration parameter is in units of gravity
• $S_S$ for spectral response acceleration at 0.2 sec
• $S_I$ for spectral response acceleration at 1.0 sec
• Shortcut to Seismic Design Category A:
  - $S_S < 0.15$ and $S_I < 0.04$
**Ground Motion Parameters & Seismic Hazard**

*Mapped Contours of $S_s$*

$s_s$ and $s_1$ are the mapped 2% in 50 year spectral accelerations for firm rock

$s_{ds}$ and $s_{d1}$ are the design level spectral accelerations (modified for site and “expected good performance”)

---

FEMA 451B Topic 5b Notes

Ground Motion Maps 4
Location of Deterministic Areas
The USGS probabilistic maps are generally rendered in color. But the MCE maps for use with codes are usually rendered in black and white.
CD vs Internet

- Internet
- CD
- Both sources give the same answers
- Both sources have a similar user interface
- The graphics are somewhat different
Internet Ground Motion Tool

http://earthquake.usgs.gov/research/hazmaps/

SEISMIC DESIGN VALUES FOR BUILDINGS
$S_s$ and $S_t$, Hazard Curves, Uniform Hazard Spectra, and Residential Design Category

Please note that the USGS is constantly changing its web-based tools, and the following slides may or may not reflect the current information on the web. Also, the web site shown above may not be current. Google “USGS Seismic Hazard Maps” to locate the latest information.
USGS Ground Motion Calculator
Welcome to the Earthquake Ground Motion Design Parameters 5.0.0 installation program.

Setup cannot install system files or update shared files if they are in use. Before proceeding, we recommend that you close any applications you may be running.
Installation Caution

Do you want to copy the data files?
These files use approximately 1.25 GB of disk space and
are necessary to run the EqGM software. If you select No,
the software can still be run but you will need to insert the EqGM
DVD into the computer’s DVD drive when running the program.

Otherwise please copy the directory 2006/USGSGroundMotionDataFiles
from the DVD after the program is installed.

[OK] [Cancel]
Seismic Hazard Curves, Response Spectra, and Design Parameters

This program allows the user to obtain hazard curves, uniform hazard response spectra, and design parameters for sites in the 50 states of the United States, Puerto Rico, and the U.S. Virgin Islands. Additionally, design parameters are available for Guam and American Samoa. Ground motion maps are also included in PDF format.

Detailed explanation of the analyses available is included in the help menu above. Click on OK to begin calculations.

Correct application of the data obtained from the use of this program and/or maps is the responsibility of the user. This software is not a substitute for technical knowledge of seismic design and/or analysis.
Analysis Options

Earthquake Ground Motion Parameters

File: Project Name: 

Analyses Options:
- USGS Probabilistic Hazard Curves
- USGS Uniform Hazard Response Spectra
- IPEI Recommended Provisions for Seismic Regulations for New Buildings and Other Structures
- International Building Code
- NFPA 5000 Building Construction and Safety Code

Select Site Location - See Site Location Rates

Latitude: Longitude: Zip Code:

Calculate Design Parameters
- Ground Motion Parameters
  - Calculate Sa and SI
  - Calculate SM and SD Values

Calculate Design Spectra
- Map Spectrum
- Site Modified Spectrum
- Design Spectrum
- View Spectra

Output for Calculations

Clear Output
View Maps
IBC Option

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 15
Calculate $S_S$ AND $S_1$
Location By Zipcode
Calculate Site Coefficients

- Soil Factors as a Function of Site Class and Spectral Acceleration
- Values of $f_a$ as a Function of Site Class and $S_s$ for NEERI Spectral Acceleration

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_s = 0.05$</th>
<th>$S_s = 0.25$</th>
<th>$S_s = 0.75$</th>
<th>$S_s = 1.00$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>C</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>D</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>E</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>a</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

- Values of $f_a$ as a Function of Site Class and $S_s$ for NEERI Spectral Acceleration

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$S_s = 0.10$</th>
<th>$S_s = 0.30$</th>
<th>$S_s = 0.70$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>C</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>D</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>E</td>
<td>0.6</td>
<td>0.8</td>
<td>0.8</td>
</tr>
<tr>
<td>F</td>
<td>a</td>
<td>a</td>
<td>a</td>
</tr>
</tbody>
</table>

Notes:
One straight-line interpolation for intermediate values of $S_s$ and $S_s$.

Spectral Accelerations:
- Site Class A
- Site Class B
- Site Class C
- Site Class D
- Site Class E
- Site Class F

Interpolated soil factors for NEERI conditions shown. Values may also be entered manually.

$S_s = 0.10$ $S_s = 0.30$ $S_s = 0.70$

$S_s = 1.00$ $S_s = 2.00$ $S_s = 3.00$ $S_s = 4.00$ $S_s = 5.00$

Note: Site-specific geotechnical investigation and dynamic site response analysis shall be performed.
$S_{MS}$, $S_{M1}$, $S_{DS}$, $S_{D1}$ Values

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 21
Calculate MCE Spectrum

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 22
Calculate $S_M$ Spectrum
### Calculate $S_D$ Spectrum

#### Earthquake Ground Motion Parameters

<table>
<thead>
<tr>
<th>Analysis Options</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Select Geographic Region</strong></td>
<td></td>
</tr>
<tr>
<td>Continental 48 States</td>
<td></td>
</tr>
<tr>
<td><strong>Select Edition</strong></td>
<td></td>
</tr>
<tr>
<td>2008 International Building Code</td>
<td></td>
</tr>
<tr>
<td><strong>Select Site Location: See Site Location Notes</strong></td>
<td></td>
</tr>
<tr>
<td>Latitude-Longitude (Recommended)</td>
<td>Zip Code</td>
</tr>
<tr>
<td>California</td>
<td>94001</td>
</tr>
</tbody>
</table>

#### Calculate Design Parameters

<table>
<thead>
<tr>
<th>Ground Motion Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate Sa and SI</td>
<td></td>
</tr>
<tr>
<td>Calculate SM and SD Values</td>
<td></td>
</tr>
</tbody>
</table>

### Design Spectra

<table>
<thead>
<tr>
<th>Spectra Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design Spectrum</td>
<td></td>
</tr>
<tr>
<td>Site-Modified Spectrum</td>
<td></td>
</tr>
</tbody>
</table>

---

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 24
Graphic Options

Instructional Materials Complementing FEMA 451, Design Examples
Map Spectrum: $S_a - T$
All Spectra: $S_a - T$

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 27
Calculate Hazard Curves

Ground Motion Parameters

Select Geographic Region
- Continuous All States
- [Select Option]

Select Edition
- [Select Option]

Select Site Location
- Latitude/Longitude Recommended
- Zip Code
- [Select Option]

Hazard Curve
- Peak Ground Acceleration
- [Calculate/View]

Single Hazard Values
- [Calculate/View]

Instructional Materials Complementing FEMA 451, Design Examples
Ground Motion Maps 5b - 28
Annual Frequency of Exceedance

Table: Annual Frequency of Exceedance on Peak Ground Acceleration

<table>
<thead>
<tr>
<th>Annual Exceedance (%)</th>
<th>Peak Acceleration (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1%</td>
<td>0.061</td>
</tr>
<tr>
<td>2%</td>
<td>0.093</td>
</tr>
<tr>
<td>5%</td>
<td>0.197</td>
</tr>
<tr>
<td>10%</td>
<td>0.379</td>
</tr>
<tr>
<td>20%</td>
<td>0.758</td>
</tr>
<tr>
<td>30%</td>
<td>1.225</td>
</tr>
<tr>
<td>40%</td>
<td>1.784</td>
</tr>
<tr>
<td>50%</td>
<td>2.343</td>
</tr>
<tr>
<td>60%</td>
<td>2.902</td>
</tr>
<tr>
<td>70%</td>
<td>3.461</td>
</tr>
<tr>
<td>80%</td>
<td>4.020</td>
</tr>
<tr>
<td>90%</td>
<td>4.579</td>
</tr>
<tr>
<td>95%</td>
<td>5.138</td>
</tr>
</tbody>
</table>

Instructional Materials Complementing FEMA 451, Design Examples

Ground Motion Maps 5b - 29
Return Period

![Graph of Peak Ground Acceleration vs Return Period](image)

### Return Period Data

<table>
<thead>
<tr>
<th>Return Period</th>
<th>Sa</th>
<th>g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.155</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0073</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
<tr>
<td>0.001</td>
<td>0.0499</td>
<td></td>
</tr>
</tbody>
</table>

**Instructional Materials Complementing FEMA 451, Design Examples**

**Ground Motion Maps 5b - 30**
Deaggregation

• Breaking apart of the probabilistic hazard analysis
• Helps remove some of the “black box” effect
• Helps visualize the source of the hazard
• Many uses, e.g. liquefaction analysis, time history determination
Deaggregation – San Francisco

Prob. Seismic Hazard Deaggregation
San Francisco  122.4170 W,  37.7790 N
Peak Int. Ground Accel. >0.141 g
Ann. Exceedance Rate: 405/645; Return Time 2415 years
Deaggregation - Coos Bay, Oregon

Prob. Seismic Hazard Deaggregation
Coos_Bay_OR: 124.2166° W, 43.3680° N,
5% period 0.20 sec. Asal=8.675 g
Aeq. Epicentral Dist. 4080.00. Mean Return Time 3475 yrs
Mean (R,Meq,0) 15.9 km, 8.14, 1.06, 1.59
Deaggregation - Portland, Oregon

Prob. Seismic Hazard Deaggregation
Portland, OR 122.6750° W, 45.3240 N.
SA period 0.30 sec, Accel. >=0.380 g
Ann. Exceedance Rate: 0.00-05, Mean Return Time: 2475 yrs
Mean (R,M,sp) 33.4 km, 8.91, 1.04, 1.60

Instructional Materials Complementing FEMA 451, Design Examples
Ground Motion Maps 5b - 35
Deaggregation – Olympia, Washington

Prob. Seismic Hazard Deaggregation
Olympia, WA, 122.8200 W, 47.0450 N.
Peak Els. Ground Accel.: 0.4944 g
Ann. Exceedance Rate: 40/40/40. Return Time: 2479 years
Seattles – 0.2 sec, Detailed
Seattle – 0.2 sec

Seattle, WA
0.2 sec $S_A = 1.494$ g
2 % PE in 50 Years
Seattle – 1.0 sec

Seattle, WA
1.0 sec $S_A = 0.220$ g
10 \% PE in 50 Years
Design Values Outside the United States

- Based on GASHAP Data
- 10% PE in 50 years
- PGA only
- Estimate 2% from 10% PE by multiplying by 2.0
- $S_s = 2.5 \times PGA$
- $S_1 = PGA$
- Use site-specific studies where available
- USGS studies where available
What is GSHAP?

GLOBAL SEISMIC HAZARD MAP