Cascading Hazards in the Cascades: The Oregon Hazard Explorer for Lifelines Program (O-Help) Web GIS

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Seismic Hazards - Overview

- **Crustal faults**
  - Seattle, Tacoma, Portland Hills
  - 1962 Vancouver, WA (M5.2)
  - 1993 Scotts Mills, OR (M5.6)

- **Deep, intraslab faults (WA)**
  - 1949 Olympia EQ (M6.8)
  - 1965 Renton EQ (M6.5)
  - 2001 Nisqually EQ (M6.8)

- **Cascadia Subduction Zone**
  - Partial rupture: SW Oregon, ~400 km, with M8 to M8.5
  - Full rupture: SW Oregon to Vancouver, BC, ~1,000 km, with M9 to M9.5

Slide Courtesy of Armin Stuedlein, OSU
Seismic Hazards - Frequency

Cascadia Subduction Zone
- ~10,000yr turbidite record (Goldfinger et al 2014)
- ~ 4 clusters of activity, separated by ~1,000 yrs
- Within a cluster, EQ’s occur ~300 to 500yrs
- Last EQ was January 26, 1700…

Slide Courtesy of Armin Stuedlein, OSU
Seismic Hazards - PGA

2014 USGS Maps for 2% in 50yrs

Peak Ground Acceleration (PGA)
[Site Class B/C]

Slide Courtesy of Armin Stuedlein, OSU
Seismic Hazards - Duration

2010 Maule (Chile)

Verdugo (2012)

2011 Tohoku (Japan)

Cox et al. (2013) *Earthquake Spectra*, 29(S1)

Slide Courtesy of Armin Stuedlein, OSU
Cascading Hazards

- Ground Shaking and Amplification
- Ground Failures:
  - Liquefaction
  - Lateral Spread
  - Landslides, rockfalls
  - Settlements
- Tsunami
  Impact, Inundation, Receding, Scouring
- Threaten infrastructure and lifelines
Oregon Resilience Plan

- OSSPAC- Oregon Seismic Safety Policy Advisory Commission
- Working Groups
  - Cascadia Earthquake Scenario
  - Business
  - Energy
  - Transportation
  - Water and Waste Water
  - Communication
  - Critical Buildings
  - Coastal Communities
- DOGAMI HAZVu – General Public

July 18, 2016
User-friendly web-GIS: (O-HELP)

“Oregon Hazard Explorer for Lifelines Program” assess earthquake hazards in Oregon

• Aids engineers to quickly analyze important seismic hazard data.

• Provides recent seismic data and earthquake hazards in Oregon.

• Simple and powerful user interface, with minimal knowledge of GIS.

• Data can be queried by address or latitude/longitude

• GIS “power-users” can stream data into their GIS to analyze with other data.

http://ohelp.oregonstate.edu/
Caution!

- O-HELP does not provide values for engineering design but rather is a tool to evaluate potential hazards in the planning process preceding design.
Scenario Map Generation Methodology

HAZUS- MH 2.2 Recommendations

- Standardized methodology containing models for estimating potential losses from earthquake.

PGA Soil Result Maps

- M9.0 CSZ
  - N Lat: 45.73
  - W Long: -125.12

- M8.7 CSZ
  - N Lat: 46.25
  - W Long: -125.2

- M8.4 CSZ
  - N Lat: 44.4
  - W Long: -125.3

- M8.1 CSZ
  - N Lat: 42.7
  - W Long: -125.2
## O-HELP HAZARD REPORT

### Section I

<table>
<thead>
<tr>
<th>Site Name:</th>
<th>PDX</th>
<th>Latitude:</th>
<th>45.5882</th>
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<tbody>
<tr>
<td>Longitude:</td>
<td>-122.5913</td>
<td></td>
<td></td>
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<tr>
<td>Date:</td>
<td>7/13/2016</td>
<td></td>
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<tr>
<td>Comments</td>
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</table>

### Vicinity Map

Under Development

### Section II: General site Information

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Elevation (Meter)</td>
<td>4.9</td>
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<tr>
<td>Slope (Degree)</td>
<td>0.0</td>
</tr>
<tr>
<td>NEHRP Site Class</td>
<td>C</td>
</tr>
<tr>
<td>Site Geologic Unit</td>
<td>sediments</td>
</tr>
<tr>
<td>Site Geology Description</td>
<td>Alluvium</td>
</tr>
<tr>
<td>Site Geology Symbol</td>
<td>Qal</td>
</tr>
<tr>
<td>Age of Site Geologic unit</td>
<td>Quaternary</td>
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<tr>
<td>Distance to nearest mapped active faults (Km)</td>
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</tr>
</tbody>
</table>

### Section III: Seismic parameters - M9.0 CSZ Earthquake

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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<tbody>
<tr>
<td>Modified Mercalli Scale</td>
<td>VII</td>
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<tr>
<td>Peak Ground Acceleration (g)</td>
<td>0.18</td>
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<tr>
<td>Peak Ground Velocity (cm/sec)</td>
<td>22.4</td>
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<tr>
<td>Short Period Spectral Response (g)</td>
<td>0.36</td>
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<tr>
<td>One Second Spectral Response (g)</td>
<td>0.24</td>
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</table>

### Section IV: Hazard Rating - M9.0 CSZ Earthquake

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Risk Level</th>
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</thead>
<tbody>
<tr>
<td>Deterministic Hazard</td>
<td>Very Low</td>
</tr>
<tr>
<td>Landslide Probability</td>
<td>0%</td>
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<tr>
<td>Landslide Displacement</td>
<td>0 cm</td>
</tr>
<tr>
<td>Liquefaction Probability</td>
<td>10%</td>
</tr>
<tr>
<td>Lateral Spreading</td>
<td>30 cm</td>
</tr>
</tbody>
</table>
What is in O-Help?

• Designed the web-GIS framework on ESRI’s ArcServer
  
  • WebGIS available at: http://ohelp.oregonstate.edu/
  
• Publically released June 1, 2016
  
• Statewide Seismic Hazard Maps:
  
  • M9.0, M8.7 full margin rupture on Cascadia Subduction Zone
  
  • M8.4, M8.1 south margin rupture on Cascadia Subduction Zone
  
  • Earthquake intensity, PGA, PGV, short and long period spectral response, landslide probability, liquefaction probability, displacement due to landslides or lateral spreading
  
  • Site geology
  
  • Digital elevation model
  
  • NEHRP site class
  
  • State Landslide Inventory Database of Oregon (SLIDO)
  
  • Location of bridges and highway routes
  
  • Location of geotechnical investigations in Portland
  
  • Bridge Damage Assessments (Coming Soon)
  
• Tool for generating seismic hazard reports
  
  • Single point
  
  • Batch analysis of multiple points
Let’s see it in Action!

LIVE DEMO!
Although the hazard maps need refinement, the analysis of various scenarios highlights that:
1. The M8.7 scenario will affect bridges stronger in the southern part of the state than the M9.0 since the energy is concentrated over a smaller area.
2. Similarly, in the Portland area, the Portland Hills Fault tended to produce higher bridge damage estimates than CSZ M9.0.
3. Hence, we need to consider a variety of scenarios, not just the “BIG ONE!”
4. Ground deformations (e.g., liquefaction, landslides) will have significant effects compared to shaking, but the hazard maps need significant refinement to reduce uncertainty.
Current Limitations

Current scenario hazard maps in O-HELP have limitations:

1. Drawn at a state-wide scale (coarse resolution)
2. Based on HAZUS routines developed using earthquake hazard models from the late 1980s (but widely accepted)
3. Only consider a scenario earthquake event
4. Potential other data sources
   - Geotechnical investigations
   - Higher-resolution geology maps
   - 2014 National Seismic Hazard Mapping
Upcoming Work

- Probabilistic Maps
  - 2% in 50 year
  - 10% in 50 year
- Liquefaction
- Lateral Spreading
- Landslides

- Integration with and of lifeline data for analyses

- Geotechnical database
NCHRP Report #833 (Project 14-29)

- Assessing, Coding, and Marking of Highway Structures in Emergency Situations
- Assessment Process Manual (Management)
- Coding and Marking Guidelines Flipbook (Field Crews)
- Smart App Developer’s Guide

Emergency Situations:
- No Collapse → PDA
- Limited Use → Repair/Rebuild
- Unsafe → EI

Rapid Assessments
MBE Inspections

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