Current status of Seismic Hazard Map in Korea

2011. 11. 25.

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Earthquake Research Center
Korea Institute of Geoscience and Mineral Resources (KIGAM)
1995. 1. 17. Hyogo EQ. (M 6.9)


1997. 12. 1st PSHM made by Ministry of Construction and Transportation (Supported by Earthquake Engineering Society of Korea)

2004 Sumatra EQ. (M 9.1), 2005 Pakistan EQ.(M 7.6)

2008. 3. 28. Countermeasure Act for Earthquake Disaster
   - Recommendation for renewal of PSHM every 5 years
   - Recommendation for supplying an Active fault map

   Project Title: “Making an Active fault map and Seismic hazard map”
   - Principal Institute: KIGAM
   - Agency: National Emergency Management Agency (NEMA)
Seismic Source
- Only using Historical & Instrumental Earthquake Catalog
- Without considering the geological & geodetical data
- Without considering the incompleteness of historical earthquake catalog

Path
- Because of no adequate seismic attenuation formula for Korean peninsula,
- Using the attenuation formula of US Eastern region
- Without considering the frequency dependency

Site effect
- Without considering the site effect
## Annual objects & contents of PSHM Project

<table>
<thead>
<tr>
<th></th>
<th>1&lt;sup&gt;st&lt;/sup&gt; Year (2009)</th>
<th>2&lt;sup&gt;nd&lt;/sup&gt; Year (2010)</th>
<th>3&lt;sup&gt;rd&lt;/sup&gt; Year (2011)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual objects</strong></td>
<td>- Collect whole available seismic data and information</td>
<td>- Historical Earthquake Catalog</td>
<td>- Revision of PSHM</td>
</tr>
<tr>
<td></td>
<td>- Analysis of the previous research results</td>
<td>- Collect and sensitivity analysis of input parameters</td>
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<tr>
<td><strong>Contents</strong></td>
<td>- Analysis the present PSHM</td>
<td>- Operation of specialist committee &amp; holding the public hearing to make an unified historical earthquake catalog</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Comparison with the various procedures including foreign countries method to make Korean PSHM</td>
<td>- Sensitivity analysis of the input parameters for PSHM</td>
<td>- Preparing the Logic tree &amp; input parameter</td>
</tr>
<tr>
<td></td>
<td>- Operation of specialist committee to develop future research direction and contents</td>
<td>- Collect &amp; Analysis of the data related to the site amplification</td>
<td>- Operation of specialist committee &amp; holding the public hearing to make an PSHM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Collect &amp; Analysis of the data related to the site amplification</td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td></td>
<td>- Historical &amp; Instrumental Earthquake Catalog</td>
<td>- National PSHM</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Site amplification map for 5 metropolitan cities</td>
</tr>
</tbody>
</table>
Procedure for PSHM

1. PSHM Methodology
   - Comparison with various PSHM Methodology

2. Sensitivity Analysis of Input Parameters
   - Historical & Instrumental EQ Catalog
   - Attenuation Formula
   - Intensity-Magnitude Conversion Formula
   - Depth, etc

3. Calculation of PSHM
   - Applying Logic Tree method & Preparing the basic input data/parameter
   - Open consensus-building process
     ; Operation of specialists committee including the variety major
     ; Holing the public hearing
1. PSHM Methodology

□ Evaluation of the Spatially Smoothed Method

. Peterson, M.D., and others, 2008, United States National Seismic Hazard Maps
. Frankel, A. and others, Documentation for the 2002 Update of the National Seismic Hazard Maps
. Frankel, A. and others, 1996, National Seismic Hazard Maps

□ Evaluation of the Seismic Zoninig Method

. Cornell, C.A., 1968, Engineering seismic risk analysis
. Klugel, 2009, Probabilistic seismic hazard analysis for nuclear power plants
. KOPEC, 2003, Probabilistic seismic hazard analysis for SHINWOLSONG 1&2 nuclear power plant site.
1. PSHM Methodology

USGS PSHA Method

**Fault Source**
- Fault Information
  - Lat-Lon, Strike, Dip, Depth
  - Slip rate
  - Maximum Capable EQ Magnitude

  hazFX

Hazard Curves on a grid of lat-lon

**Point Source**
- Earthquake Catalogue
  - Regional b-value
  - Magnitude-completeness times

  hazgridX

Hazard Curves on a grid of lat-lon

hazallX

Ground Motion with specified annual frequency of exceedence
1. PSHM Methodology

Active Faults D/B

Contents: Name, Location, Fault type, Strike/Dip, Length, Displacement, Age dating, Lithology, etc.
1. PSHM Methodology

Sensitivity Analysis of PSHM using by USGS Method

- Slip Rate: 7.0 mm/year

[Length: 10km, Mmax : 6.0]  
[Length: 20km, Mmax : 6.5]  
[Length: 50km, Mmax : 7.0]

*PGA[%g] for 50 years
1. PSHM Methodology

Sensitivity Analysis of PSHM using by USGS Method

- Slip Rate: 14.0 mm/year

*PGA[\%g] for 50 years

[Length: **10km**, Mmax: **6.0**]  
[Length: **20km**, Mmax: **6.5**]  
[Length: **50km**, Mmax: **7.0**]  

*PGA[\%g] for 50 years
2. Input Data/Parameters

- **USGS(2008)**
  ; combine earthquakes from several (reformatted) source catalogs, choose one preferred record for each event that is listed more than once, and decluster to remove aftershocks and foreshocks
  - Western North America (WNA) Catalog
  - Central & Eastern North America (CENA) Catalog

- **Japan NIED(2009)**
  ; Chronological Scientific Tables (自然科学硏究機構 国立天文台 編)
  - ~1884 : Tatsuo Usami Catalog (宇佐美龍夫)
  - 1885~1925 : Tokuji Utsu (宇津德治)
  - 1926~       : JMA
2. Input Data/Parameters

\[ \text{Collection & Analysis of available earthquake list and research results} \]

- 嚴相鎬 (1978), 金昭九 (1978)
- 鄭鳳一 (1981)
- 韓國動力資源研究所 (1983)
- 朝鮮地震研究所 (1984, 1987)
  : 2,186 historical earthquake list
- 慶在福 (1989, 2009)
  : 2,113 historical EQ. List
- 建設交通部 (1997)
- 國立防災研究所 (1999)
- 原子力安全研究院 (2000)

2. Input Data/Parameters

- **Historical EQ D/B Construction**
  - Collect all available lists & Publications
  - Collect EQ information from National & University D/B related to historical record
  - Adjacent countries D/B and List
2. Input Data/Parameters

- Setup specific criteria for
  - Unified Event List
  - Epicenter determination
  - Intensity determination
     - Felt-area–Intensity relationship
     - According to the description for
       - Human & Animal Building (castle, fortress, house, wall, etc)
       - Natural phenomenon (surface rupture, shaking, liquefaction, etc)

- Operation of specialist committee
  - Confirmation above criterion
  - Review the final historical EQ catalog
  - Revaluation for the 64 big historical EQ

- Holding the public hearing to make an unified(acceptable?) historical earthquake catalog
## 2. Input Data/Parameters

<table>
<thead>
<tr>
<th>Organization</th>
<th>Duration</th>
<th>No. of Events</th>
<th>Data count</th>
</tr>
</thead>
<tbody>
<tr>
<td>KIGAM</td>
<td>02-08 ~ 2010-11-28</td>
<td>2437</td>
<td>857</td>
</tr>
<tr>
<td>KMA</td>
<td>1978-08-30 ~ 2010-12-20</td>
<td>918</td>
<td>918</td>
</tr>
<tr>
<td>LEE&amp;YANG</td>
<td>02-08 ~ 1904-03-23</td>
<td>1928</td>
<td>66</td>
</tr>
<tr>
<td>NK</td>
<td>27-10 ~ 1985-12-23</td>
<td>1057</td>
<td>766</td>
</tr>
<tr>
<td>NORTH KOREA</td>
<td>1905-08-25 ~ 1996-11-17</td>
<td>445</td>
<td>445</td>
</tr>
<tr>
<td>Ministry of Construction</td>
<td>27-00 ~ 1810-01-20</td>
<td>389</td>
<td>1</td>
</tr>
<tr>
<td>KYUNG</td>
<td>27-00 ~ 1810-02-19</td>
<td>449</td>
<td>1</td>
</tr>
<tr>
<td>EARLY</td>
<td>1913-05-12 ~ 1941-12-15</td>
<td>91</td>
<td>91</td>
</tr>
<tr>
<td>NEIC</td>
<td>1973-09-10 ~ 2009-08-10</td>
<td>207</td>
<td>207</td>
</tr>
<tr>
<td>ISC</td>
<td>1905-08-25 ~ 2009-05-01</td>
<td>849</td>
<td>849</td>
</tr>
</tbody>
</table>
3. PSHM Calculation

- Construction of specialist committee to conduct the logic tree evaluation, consisted of various major field
- Now, finalizing the logic tree & preparing input data and parameters
4. Site Amplification

Seismic zonations in an urban area

Earthquake By Fault Movement

Dynamic Rupture (Source effects)

Wave Propagation (Path effects)

Earthquake Ground Motion

Site effects

Minor hazards

Serious hazards

in an urban area
## Current Site Classification Scheme in Most Codes
- **Western Region of US**

<table>
<thead>
<tr>
<th>Soil Profile Type</th>
<th>Generic Description</th>
<th>Average Soil Prop. (Vs30) (m/s)</th>
<th><strong>Short-Period</strong></th>
<th><strong>Mid-Period</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>S_A (Site Class A)</td>
<td>Hard Rock</td>
<td>&gt; 1,500</td>
<td>0.09 0.82 0.05 0.71</td>
<td>0.09 0.82 0.05 0.71</td>
</tr>
<tr>
<td>S_B (Site Class B)</td>
<td>Rock</td>
<td>760 - 1,500</td>
<td>0.11 1.00 0.07 1.00</td>
<td>0.11 1.00 0.07 1.00</td>
</tr>
<tr>
<td>S_C (Site Class C)</td>
<td>Very Dense and Soft Rock</td>
<td>360 - 760</td>
<td>0.13 1.18 0.08 1.14</td>
<td>0.18 1.64 0.11 1.57</td>
</tr>
<tr>
<td>S_D (Site Class D)</td>
<td>Stiff Soil</td>
<td>180 - 360</td>
<td>0.16 1.45 0.11 1.57</td>
<td>0.23 2.09 0.16 2.29</td>
</tr>
<tr>
<td>S_E (Site Class E)</td>
<td>Soft Soil</td>
<td>&lt; 180</td>
<td>0.22 2.00 0.17 2.43</td>
<td>0.37 3.36 0.23 3.29</td>
</tr>
<tr>
<td>S_F (Site Class F)</td>
<td>Soil Requiring Site-specific Evaluation</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*C: Seismic Coefficient  F: Site Amplification Factor  Z: Seismic Zone Factor  
Short Period: 0.1 ~ 0.5 sec,  Mid-Period: 0.4 ~ 2.0 sec*
### Modification of Site Classification

<table>
<thead>
<tr>
<th>Generic Description</th>
<th>Site Class</th>
<th>Criteria</th>
<th>Site Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>$V_{S30}$ (m/s)</td>
<td>$T_G$ (s)</td>
</tr>
<tr>
<td>Rock</td>
<td>B</td>
<td>&gt; 760</td>
<td>&lt; 0.06</td>
</tr>
<tr>
<td>Weathered Rock and Very Stiff Soil</td>
<td>C</td>
<td>C1</td>
<td>&gt; 620</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C2</td>
<td>&gt; 520</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C3</td>
<td>&gt; 440</td>
</tr>
<tr>
<td></td>
<td></td>
<td>C4</td>
<td>&gt; 360</td>
</tr>
<tr>
<td>Intermediate Stiff Soil</td>
<td>D</td>
<td>D1</td>
<td>&gt; 320</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D2</td>
<td>&gt; 280</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D3</td>
<td>&gt; 240</td>
</tr>
<tr>
<td></td>
<td></td>
<td>D4</td>
<td>&gt; 180</td>
</tr>
<tr>
<td>Deep Stiff Soil</td>
<td>E</td>
<td>≤ 180</td>
<td>≥ 0.62</td>
</tr>
<tr>
<td>Deep Soft Soil</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. Site Amplification

For five metropolitan cities, Seoul, Daejeon, Gwangju, Daegu, Busan

- Building the geotechnical DB composed of the existing borehole drilling data and surface geo-knowledge data
- Implementing the GIS-based geotechnical information system for spatial geotechnical (geo-) layers using the geotechnical DB
- Creating a variety of spatial zoning maps for quantifying the site effects in terms of the site period within GIS-based tools
- Annual Target Area
  - 2010: Daejeon, Gwangju
  - 2011: Seoul, Daegu, Busan
4. Site Amplification

Geotechnical database (2010)

Daejeon: Collecting more than 1,300 existing Borehole drilling data and acquiring about 300 surface goe-knowledge data for each target area

Kwangju: More than 1,900 borehole data and about 300 surface data
4. Site Amplification

Geotechnical database (2010)

Seoul: More than 10,800 borehole data & about 900 surface data
Daegu: More than 1,800 borehole data and about 300 surface data
Busan: More than 2,900 borehole data and about 200 surface data
4. Site Amplification

**Depth to bedrock in Daegu**
- Maximum depth of deeper than 30m in Daegu basin
4. Site Amplification

**Predominant site period in Daegu**
- 0.20 to 0.35 sec in plain and valleys
  (vulnerability for 2 to 4 storied buildings during EQ)
- 100m x 100m Grid
4. Site Amplification

Site classes based on predominant site period in Daegu
- Site classes C(C1 to C4) in plains
- Max 1.90 for Fa and 1.19 for Fv => Significant Seismic amplification
Representative site classes for rapid response in Daegu

- Site classes averaged with administrative sub-unit
- Site classes C(C1 to C4) in most sub-unit => Significant seismic amplification
Final Goal

Global Seismic Hazard Assessment Program
– Region 8 Eastern Asia

Thank You !!

http://www.seismo.ethz.ch/static/GSHAP/eastasia/asiafin.gif