Probabilistic estimates of seismic hazard and public awareness in Japan

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Ettore Majorana Foundation and Centre for Scientific Culture, Erice, Sicily
Japanese earthquakes can be classified into two types.

1. Shallow crustal earthquakes

2. Subduction zone earthquakes

Intraplate normal-fault eq.
Intraplate reverse-fault eq.
Evaluation of earthquake potential

<table>
<thead>
<tr>
<th>Identifiable sources</th>
<th>Subduction-zone EQ</th>
<th>Shallow crustal EQ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time-dependent &amp; time-independent long-term forecasts</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Unidentifiable ones</th>
<th>Smaller-than-the largest EQ</th>
<th>Distributed sources</th>
</tr>
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<tbody>
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For distributed sources, we sum up results of spatial smoothing and zoning methods by using small & moderate eq.

Source interactions are alluded to but no probability is given except for Tokai, Tonankai, Nankai earthquake sequence.
Evaluation of earthquake potential

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<th>Subduction-zone EQ</th>
<th>Shallow crustal EQ</th>
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<tbody>
<tr>
<td><strong>Identifiable sources</strong></td>
<td>Av. repeat time ~100 yrs</td>
<td>Av. repeat time ~1000 yrs or more</td>
</tr>
<tr>
<td></td>
<td>Historical eq data</td>
<td>Active fault survey</td>
</tr>
<tr>
<td><strong>Unidentifiable ones</strong></td>
<td>Smaller-than-the largest EQ</td>
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Source interactions are alluded to but no probability is given except for Tokai, Tonankai, Nankai earthquake sequence.
Small probabilities for EQ on active faults

The figure taken from news article of Kyodo News Agency shows why much smaller probabilities are obtained for earthquakes on active faults relative to earthquakes along the oceanic trench.

Probability less than 10% tends to be neglected by general public
Classification of small probabilities and verbal expression are necessary because small probability does not mean safe.

The 30-yr probability could have been evaluated as only 0.02-8%, if the estimate had been made just prior to the Kobe earthquake.

- High probability relative to other active fault zones: 3% or higher (30yr probability)
- Slightly high probability: 0.1-3%
- No comments: less than 0.1%

The largest probability is used when the range of probability is estimated.

Earthquake Research Committee, 2003
Help to understand meaning of probability level

Earthquake Research Committee, 2003; translated by Midorikawa, 2006
Summary of earthquake forecasts for the 98 major active fault zones (159 faults/ fault segments)

159 faults/faults segments

116 cases with 30-yr probability

- Model used
- Comment

Long-term Evaluation Subcommittee, 2005
30-yr probability

Long-term forecasts for the major 98 fault zones was made public by April 2005.

Long-term Evaluation Subcommittee, 2005
30-yr probability

Long-term forecasts for the major 98 fault zones was made public by April 2005.

Binary response
safe or dangerous
take measures or not

We need recipe.

<table>
<thead>
<tr>
<th>uncertainty</th>
<th>probability</th>
<th>Various EQ measures</th>
</tr>
</thead>
</table>

Long-term Evaluation Subcommittee, 2005
Forecast summary of earthquakes along the oceanic trenches

Identifiable source
- Time-predictable with disturbances  2
- Brownian Passage Time model       15
- Poisson Process (unknown last event)  2

Unidentifiable source
- Poisson Process                      14
The probability is estimated on the basis of the time-predictable model with disturbances.

Earthquake Research Committee, 2001
30-yr probability: Nankai Earthq
Seismic Intensity: Nankai + Tonankai (Central Disaster Prevention Council, 2003)

- 30yr probability
- Nankai eq 50%, Tonankai 60-70%

M.M. Intensity

10, 11, 12
9-10

30yr probability
Nankai eq 50%, Tonankai 60-70%
Estimated number of collapsed buildings per km$^2$.

(Central Disaster Prevention Council, 2003)
Historical damaging earthquakes: Identifiable and unidentifiable sources

- 98 major active fault zones: identifiable source
- 50% of inland damaging events which killed more than 50
- 70% of those which killed more than 1,000

- Other identifiable source
  - Most off-shore earthquakes which killed more than 50

- Unidentifiable source
  - Earthquakes occurring away from active faults
  - Smaller off-shore earthquake
  - Deep earthquakes

- Earthquakes on active fault other than the 98 major fault zones (Identifiable, but inaccurate forecast)

Statistics based on the past 200 year data
The 1995 Kobe earthquake

The present top issue is existing weak houses and buildings
Most of the collapsed houses were built prior to the 1981 building code revision.

Investigation shows that 64% of houses built, following the former building code, before 1982 were destroyed by the earthquake. It is very important to retrofit these houses.
<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>2003</th>
<th>H10→H15</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong># of houses</strong></td>
<td>44M</td>
<td>47M</td>
<td>+300万戸</td>
</tr>
<tr>
<td><strong>Unsafe</strong></td>
<td>14M</td>
<td>11.5M</td>
<td>-250万戸</td>
</tr>
<tr>
<td></td>
<td>32%</td>
<td>25%</td>
<td></td>
</tr>
<tr>
<td><strong>Wooden houses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>内</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>耐震性が不十分</td>
<td>2,350万戸</td>
<td>2,450万戸</td>
<td>+100万戸</td>
</tr>
<tr>
<td></td>
<td>1,200万戸</td>
<td>1,000万戸</td>
<td>-200万戸</td>
</tr>
<tr>
<td></td>
<td>51%</td>
<td>41%</td>
<td></td>
</tr>
<tr>
<td>訳</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>耐震性が不十分</td>
<td>2,050万戸</td>
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</tr>
<tr>
<td></td>
<td>200万戸</td>
<td>150万戸</td>
<td>-50万戸</td>
</tr>
<tr>
<td></td>
<td>10%</td>
<td>7%</td>
<td></td>
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</table>
GOAL: 25% unsafe houses/buildings should be decreased to 10% within 10 years.

How can we reach the goal?

What would be the best incentive to make people retrofit or rebuild their dwellings?

Example

Tax deduction for earthquake insurance premium starts from this fiscal year and two years later the present tax reduction for fire insurance (fire caused by earthquakes is not insured) premium will be abolished.

Which weak house/buildings should we choose for retrofit or rebuilding?

Probabilistic seismic hazard map answers this question.
The first national seismic hazard map is produced ten years after the Kobe eq. on the basis of long-term forecasts and empirical attenuation relationship.
Japan Seismic Hazard Information Station (J-SHIS)

Shake map for M7.2 Miura Peninsula Fault Zone EQ

Intensity estimate in Yokosuka city on its HP

Tonankai-Nankai EQ
30-yr probability: 60-70%

Itoigawa-Shizuoka Tectonic Line fault zone
30-yr probability: 14%

Seismic Intensity
M.M. 9-10, 10-

Number of collapsed buildings / km²
500 - 3,000
200 - 500
100 - 200
30 - 100
10 - 30
1 - 10
Do you feel the necessity of earthquake measures?

Matsumoto
(Fault EQ 14% in 30yrs)

Nagoya
(Subduction EQ 60-70% in 30yrs)

Headquarters for Earthquake Research Promotion, 2006
General comments may not be sufficiently persuasive to make people prepare for earthquake disasters.

One way is to make statements very specific. If you are told that your house will collapse when a certain earthquake hits, you would start to think about it.

Long-term earthquake forecasts, realizable at the present level of our knowledge, are helpful and the first step towards our goal.
Retrofit Construction of ERI building
February 2007