ESTIMATION of PML for BUILDINGS with VARIOUS STRENGTHS in JAPAN

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Introduction

• Numerical examples of PML in Japan: regional differences and various strengths.
• 15% as PML is acceptable for financing.
• Annual expected loss, percentile values of loss estimates are compared with PML.
• Interest rates should depend on the risk level corresponding to PML.
Example of seismic hazard

Seismic hazard in terms of PGV 10% in 50 years

Ochi et al, 2002
Fig. 1 Earthquake Hazard Curve

Annual Exceedance Probability

PGV (cm/s)

Sapporo
Sendai
Tokyo
Osaka
Fukuoka
Uncertainty was increased from 0.6 to 0.67 in terms of logarithmic s.d.
Difference of strength in fragility

\[ \lambda_i = \ln \frac{I_s V_o}{0.4} \]

where

\( I_s \) is the seismic resistance index

<table>
<thead>
<tr>
<th></th>
<th>slight</th>
<th>minor</th>
<th>moderate</th>
<th>severe</th>
<th>collapse</th>
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<tbody>
<tr>
<td>Vo</td>
<td>50</td>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
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Vo in m/s

Hayashi et al 2000
Statistics of damage cost for three damage levels are considered to construct the loss function.

- Minor damage: 10,000 yen/m²
- Medium damage: 15,000 yen/m²
- Major damage: 55,000 yen/m²

Statistical data due to Kanda 1999.
Fig. 3 Distribution of Damage Loss for Each Damage Level

Probability Density

Repair Cost (x10000 yen/m²)

Minor
Moderate
Severe

Model Constructed based on Kanda 1999

Second IFED Forum, April 26-29, 2006,
PML for 475 year event

\[
p_{PML}(r) = \sum_i \left\{ f(i, V_{475}) \cdot \phi \left( \frac{\ln(r) - \lambda_{ri}}{\zeta_r} \right) \right\}
\]

where

\[
f(i, v) = \begin{cases} 
\Phi \left( \frac{\ln(v) - \lambda_i(Is)}{\zeta_f} \right) - \Phi \left( \frac{\ln(v) - \lambda_{i+1}(Is)}{\zeta_f} \right) & i = 1, 2, \ldots, n - 1 \\
\Phi \left( \frac{\ln(v) - \lambda_i(Is)}{\zeta_f} \right) & i = n 
\end{cases}
\]

and \( r \) is the ratio of the repair cost to the initial cost (loss ratio)
Fig. 4 loss ratio and its annual exceedance probability
Fig. 5 PML Values for a recurrence period of 475 years

PML (%)
Fig. 6  PML Values for a recurrence period of 2475 years
PML and AEL

\[ PML = r \bigg|_{P_{PML}(r)=0.9} \]

where

\[ P_{PML}(r) = \int_{0}^{r} p_{PML}(r) dr \]

\[ AEL = \int_{0}^{\infty} r p_{all}(r) dr \]

where

\[ p_{all}(r) = \sum_{i} \left\{ \int_{0}^{\infty} f(i, v) \cdot \phi \left( \frac{\ln(r) - \lambda_{ri}}{\zeta_{r}} \right) dv \right\} \]
Fig. 7 AEL Values Compared to PMLs

AELs (%) vs. PMLs (%)
Percentile estimates for loss

\[ f_{99} = r \bigg| P_{all}(r) = 0.99 \]

where

\[ P_{all}(r) = \int_{0}^{r} p_{all}(r) dr \]
Fig. 8  90 and 99 Percentile of Loss Ratio estimates compared to PMLs
# Variable interest rate proposal

<table>
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<tr>
<th>l_s</th>
<th>0.3</th>
<th>0.6</th>
<th>0.9</th>
<th>0.3</th>
<th>0.6</th>
<th>0.9</th>
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<tr>
<td>PML(%)</td>
<td>20.6</td>
<td>7.6</td>
<td>0</td>
<td>31.8</td>
<td>13.9</td>
<td>4.3</td>
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<td>99% loss</td>
<td>3.58</td>
<td>0.57</td>
<td>0.09</td>
<td>5.94</td>
<td>1.13</td>
<td>0.22</td>
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<td>interest rate (%)</td>
<td>6.7</td>
<td>3</td>
<td>3</td>
<td>8.9</td>
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<td></td>
<td>2.5</td>
<td>2.1</td>
<td></td>
<td>3.2</td>
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Tokyo Osaka
Conclusions

1. PML values with various strengths at 5 sites in Japan were estimated.
2. Is index may be used as an structural performance measure for existing buildings in Japan.
3. Annual expected loss and percentile estimate loss are compared with PML.
4. Variable interest rates are proposed.