Building Damages
Damages of Non-Structural Components
Damages of Building Utilities
Loss Estimation Model – Vulnerability Curve

Loss Amount = Replacement Cost \times \text{Loss Ratio}

Loss Ratio

Ground Motion

JMA Seismic Intensity 6.4 (◻ + )

Loss Ratio 20%
Levels of Analysis Rigor

- **Three Levels**
  - **Level 1** Statistical “desk top” analysis
    - Replacement Value
    - Location
    - Construction Class
    - Year Build
    - # of Stories
    - Occupancy
  - **Level 2** Enhanced analysis based on engineering review of design drawings and calculations. Yields customized performance modeling
  - **Level 3** Level 2 with inspection to determine “as-built” condition vs. original design. Yields customized performance modeling. Most rigorous, yet cost-effective assessment of risk.

- Combination of different levels
Level-3 Analysis – Break down a Building to Components

Constructional Element of a Building

- Beam, Columns
- Earthquake-resisting wall
- Exteriors
- Partition walls
- Ceilings
- Electrical equipment
- Pipes, Ducts
  etc.

Structural Components: Damaged by Horizontal Force
- Beam, Columns
- Earthquake-resisting wall etc.

Non-Structural Components: Damaged by Deformation
- Exteriors
- Partition walls
- Pipes, Ducts etc.

Non-Structural Components: Damaged by Acceleration
- Ceilings
- Electrical equipment etc.
Response Analysis and Loss Estimation of Damaged Components
Various Analysis Levels for Loss Estimation

It is important to select a right method to meet objectives by considering amount of information and cost.

Level One
(Desktop)

Level Two
(Expert Opinion)

Level Three
(Engineering Review, Inspection)

Sophisticate Analysis
- Rupture Source Model
- 3D Dynamic Analysis
- Non Linear Dynamic Analysis
Probability Distribution at 10% of Mean Loss (Secondary Uncertainty)

Median = 9.0%
Mean = 10%
90 percentile = 17.6%

Level Three Analysis
- Ground Motion
- Vulnerability Curve
- Probability Distribution at 10% of Mean Loss
- Secondary Uncertainty

Level One Analysis
- Median = 3.8%
- 90 percentile = 29.7%
Portfolio Effect
Change of Uncertainty by Summing

Mean Loss Ratio = 10%

Probability density distribution at N=20 is almost equivalent with Level-3 analysis.
Portfolio Effect

Risk Concentration
- Tokyo
- Chiba
- Yokohama

Add to Loss axis direction

Risk Diversification
- Tokyo
- Aomori
- Osaka

Add to Probability axis direction
Business Interruption Model

- Building/ Facility Damage
- Occupancy
- Days of Downtime
- Lifeline Damage
- Lifeline Importance Factors
- Business Interruption Loss
- Business Interruption Model
Facility Restoration Function – BI Model

BI Loss = Days of Downtime \( \cdot \) Income per Day

Total Days of Downtime
Facility Restoration Function
(Specific Occupancy Class)
Casualty Model

Exposure Data

Simulated Catastrophic Events

Casualties & Losses by event for Risk Curve

- Geographic distribution of people, building type, time of day
- Building damage and collapse distributions by building type; population injured, entrapped, rescued, and injury distributions
- Treatment costs insurance claims settlements

Insurance claims settlements

Risk Management OYORMS
# Scenario Results

## Kobe, 1/17/1995, 5:46, M7.2

<table>
<thead>
<tr>
<th>Estimated Actual</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary Total</td>
<td>8,000</td>
</tr>
<tr>
<td>PP-minor</td>
<td>2,400</td>
</tr>
<tr>
<td>PP-major</td>
<td>1,000</td>
</tr>
<tr>
<td>Permanent Total</td>
<td>300</td>
</tr>
<tr>
<td>Fatalities</td>
<td>5,500</td>
</tr>
</tbody>
</table>

## Niigataken-Chuetsu, 10/23/2004, 17:56, M6.8

<table>
<thead>
<tr>
<th>Estimated Actual</th>
<th>Modeled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serious</td>
<td>635</td>
</tr>
<tr>
<td>PP-minor</td>
<td>45</td>
</tr>
<tr>
<td>PP-major</td>
<td>15</td>
</tr>
<tr>
<td>Permanent Total</td>
<td>1</td>
</tr>
<tr>
<td>Fatalities</td>
<td>25</td>
</tr>
</tbody>
</table>
Estimated Loss of each Stochastic Events

- Mean loss
- 90 percentile loss
## Event Curve

<table>
<thead>
<tr>
<th>Event #</th>
<th>Estimated Loss (billion Yen)</th>
<th>Annual Probability of Event Occurrence</th>
<th>Cumulative Annual Probability of Exceedance</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>868-01M8.25</td>
<td>0.100%</td>
<td>0.100%</td>
</tr>
<tr>
<td>2</td>
<td>877-01M8.10</td>
<td>0.142%</td>
<td>0.241%</td>
</tr>
<tr>
<td>3</td>
<td>865-01M7.90</td>
<td>0.290%</td>
<td>0.530%</td>
</tr>
<tr>
<td>4</td>
<td>867-03M7.20</td>
<td>0.177%</td>
<td>0.706%</td>
</tr>
<tr>
<td>5</td>
<td>867-02M7.20</td>
<td>0.172%</td>
<td>0.877%</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

The diagram illustrates the probability of exceeding a specific loss level event curve, with events numbered 1 to 5 and probabilities ranging from 0.100% to 0.877%.
Interpretation on Event Curve

Annual Average Loss (AAL)

\[ \text{AAL} = \sum (\text{Estimated Loss} \times \text{Annual Probability of Occurrence}) \]
\[ = \sum (\text{Estimated Loss} / \text{Return Period}) \]

- **Expected Loss per Year**

At least, ¥8.2 billion is expected within the next 100-year period

Worst case scenario ¥13.6 billion
Loss Distribution Reflects Potential Levels of Damage from a Single Event

- 90 percentile loss
- Mean loss

Annual Exceedance Probability vs. Estimated Loss
Risk Curve
Exceedance Probability Curve with Secondary Uncertainty

Annual Exceedance Probability vs. Estimated Loss

Exceedance Probability Curve with Secondary Uncertainty
Event Curve vs. Risk Curve

Event Curve: Event Occurrence
Risk Curve: Loss Occurrence

Substantial Difference on Annual Exceedance Probability
Aggregation of Risks

- CAT Risk
- Non-CAT Risk
- Market Risk
- Financial Risk
- Credit Risk
- Operation Risk

Correlation

Aggregations

Aggregated Risk
Event Curve vs. Risk Curve

- Event Curve (Mean)
- Risk Curve with Small Uncertainty
- Risk Curve with Large Uncertainty

Annual Exceedance Probability vs. Estimated Loss (billion Yen)
TCE (Tail Conditional Expectation)

\[ \text{Annual Exceedance Probability} \]

- \( Lp \) = Estimated Loss (billion Yen)
- \( \rho \) = Annual Exceedance Probability
- \( Ep \) = Expected Loss (AAL)
- \( Ep / \rho \) = TCE Curve

Expected Loss (AAL): \( Ep \)

Risk Management OYORMS
TCE (Tail Conditional Expectation)

Risk Curve with Secondary Uncertainty
Event Curve (Mean)
Event Curve (90 percentile)
TCE Curve

Annual Exceedance Probability

Estimated Loss (million Yen)
Estimated Losses and Financial Statements

**Loss by Physical Damages**
- Losses by facility damages
  - Repairing Cost
  - Dismantlement Cost, etc.
  - Restoration Cost excluding the above (Asset Capitalization)
  - Loss of Booked Values
- Damages of Inventory Assets

**Losses by Business Interruptions**

<table>
<thead>
<tr>
<th>Balance Sheet (Assets Side)</th>
<th>Income Statement (P/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depletion of Cash</td>
<td>Extraordinary Loss / Non-operating Expense</td>
</tr>
<tr>
<td>Depletion of Cash</td>
<td>Amortization</td>
</tr>
<tr>
<td>New Asset (after recovery)</td>
<td></td>
</tr>
<tr>
<td>Depletion of Fix Assets</td>
<td>Extraordinary Loss</td>
</tr>
<tr>
<td>Depletion of Liquid Asset</td>
<td>Extraordinary Loss</td>
</tr>
<tr>
<td>Depletion of Cash</td>
<td>Drop in Sales/Profit</td>
</tr>
<tr>
<td>Depletion of Earnings</td>
<td></td>
</tr>
</tbody>
</table>
Study on Risk Measures by Using Risk Curve of Equity Capital

- Risk Curve at Present
- Acceptable Limit of Equity Capital Depletion
- Possible Occurrence with P% Probability
- Require 2.5 billion yen to recover equity capital by insurance or others
- P% of probability as the worst case scenario for the study
Study on Risk Measures by Using Risk Curve of Equity Capital

As 3 B Yen is in acceptable range, additional financial measure is not required.
Conclusions

- Assessment technology on Seismic Risk has already reached at a certain level of probabilistic approach.
- Utilizing existing models is more efficient way to build specific risk models for financial institutes
  - First, a perspective model and then move to a detailed model
  - Implementing uncertainties adequately is very important for risk modeling.
- Losses by earthquake will spread geographically and temporally
  - Limiting seismic risk to operational risk is an appropriate way?