Earthquake Risk and Its Reduction Technology in Japan

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Agenda

• Earthquake Risk of Tokyo Metropolitan
• Lessons from the 1995 Kobe Earthquake
• Earthquake Risk Reduction Technology
  Building Response Control
  Earthquake Information System
Natural Hazard Risk Index
(Munich Re, 2005)

Natural Hazard Risk Index = Hazard × Vulnerability × Exposure

Hazard

Japan is one of the most earthquake-prone countries.
Exposure of Tokyo Metropolitan

<table>
<thead>
<tr>
<th></th>
<th>Population</th>
<th>Wooden Houses</th>
<th>Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tokyo</td>
<td>12,700,000</td>
<td>1,800,000</td>
<td>1,900,000</td>
</tr>
<tr>
<td>Kanagawa</td>
<td>8,900,000</td>
<td>1,600,000</td>
<td>880,000</td>
</tr>
<tr>
<td>Saitama</td>
<td>7,100,000</td>
<td>1,600,000</td>
<td>510,000</td>
</tr>
<tr>
<td>Chiba</td>
<td>6,100,000</td>
<td>1,400,000</td>
<td>400,000</td>
</tr>
<tr>
<td>Total</td>
<td>34,800,000</td>
<td>6,400,000</td>
<td>3,700,000</td>
</tr>
</tbody>
</table>

Loss Estimation for Tokyo Earthquake by Central Disaster Prevention Council (2005)

Direct Loss $560billion
  Buildings $470billion,
  Infrastructures $90billion
Indirect Loss $380billion
  Decrease in Products $330billion
  Effects of Interruption of Transportation $50billion

Total Loss $940billion
Lessons from the 1995 Kobe earthquake

Dead 6,400  
Injured 40,000  
Damaged Buildings 250,000  
Direct Monetary Loss $100billions

Catastrophic damage was observed in the disastrous belt zone along the fault.
Most of casualties were caused by collapse of buildings and overturning of building contents.

However, no severe damage was observed at new buildings in the disastrous belt zone.
Information

- Just after the Kobe earthquake, available information was very limited.

For example, the evening newspaper of the day reported that 200 were killed by the earthquake, however the final number of fatalities reached 6,400.

Due to lack of prompt information on the disaster, governments could not take immediate emergency response.

After the earthquake, the importance of earthquake and disaster information was strongly recognized.
Lessons from the Kobe Earthquake

1. Importance of upgrading seismic performance of buildings

2. Importance of prompt information on earthquake and disaster

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**E–defense**

(Largest Shaking Table in the World)

Completed on Jan., 2005,
Construction Period: 5 years, Construction Cost: 400 million $

<table>
<thead>
<tr>
<th>Items</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. Capacity</td>
<td>1,200ton</td>
</tr>
<tr>
<td>Table Size</td>
<td>20m × 15m</td>
</tr>
<tr>
<td>Drive System</td>
<td>Oil Accumulator</td>
</tr>
<tr>
<td>Direction</td>
<td>Horizontal, Vertical</td>
</tr>
<tr>
<td>Peak Acc.</td>
<td>900cm/s²以上, 1,500cm/s²以上</td>
</tr>
<tr>
<td>Peak Vel.</td>
<td>200cm/s, 70cm/s</td>
</tr>
<tr>
<td>Peak Disp.</td>
<td>± 100cm, ± 50cm</td>
</tr>
</tbody>
</table>
Examples of Seismic Retrofit of Buildings

Design Conscious Seismic Retrofit

Seismic Retrofit of Building by Energy-dissipated Brace Concealed by Outer Skin

Building Reform and Renovation Award
Takeuchi Laboratory
Base-Isolation System

Rubber Bearing laminated by rubber and steel sheets

The WEST building located about 15km north of the fault of the Kobe earthquake.

Acceleration Time Histories (NS comp.)
Total Number is about 2000

Number of Base-Isolated Buildings

Total Number is about 2000

Number of Base-Isolated Houses

Base-Isolated Town

21 Buildings on Base-Isolated Ground of 15,000 m² with 242 Rubber Bearings and Sliders
Seismic Retrofit by Isolation System

Structural Response Control System
4000 buildings
Earthquake Information System

P-waves → Earthquake Detection → Alarm & Control → Damage Assessment → Decision Making

S-waves

With Damper

Without Damper
Pioneer of Earthquake Alarm System
UrEDAS
(Urgent Earthquake Detection and Alarm System)

The project was started in 1975.
The prototype was developed in 1983.
The operation for the Bullet Train was started in 1990.

EARTHQUAKE EARLY WARNING SYSTEM BY JMA
The Earthquake Early Warning system provides advance announcement of the estimated seismic intensities and expected arrival time of principal motion. These estimations are based on prompt analysis of the focus and magnitude of the earthquake using wave form data observed by seismographs near the epicenter.
The Earthquake Early Warning is aimed at mitigating earthquake-related damage by allowing countermeasures such as promptly slowing down trains, controlling elevators to avoid danger and enabling people to quickly protect themselves in various environments such as factories, offices, houses and near cliffs.

Example of Prompt Earthquake Information
Real-Time Damage Assessment

Based on monitoring of ground shaking, locations of damage areas and safer areas are assessed in real-time for speedy and adequate emergency response activities.

Flow of Seismic Hazard and Risk Assessment

**Ground Shaking Map and Liquefaction Map** are evaluated from ground motion data together with soil data.

**Building Damage Map** is evaluated from building data and ground shaking map.
Disaster Information System by Central Government

In 1996, the National Land Agency was developed the nationwide damage assessment system based on the ground motion data from the J.M.A.
Many local governments have also developed their systems.

Summary

- Tokyo has high seismic hazard and large exposure, resulting high seismic risk.
- Technologies are being developed in order to improve vulnerability of our society such as high seismic performance buildings and earthquake information systems.