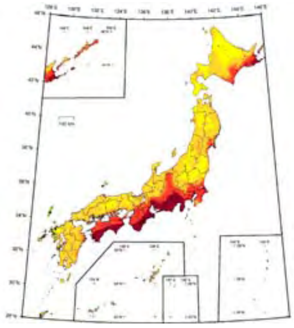
Earthquake Risk and Its Reduction Technology in Japan



Prof. S. Midorikawa
Center for Urban Earthquake Engineering
Tokyo Institute of Technology

Tokyo Tech CUEE

Agenda

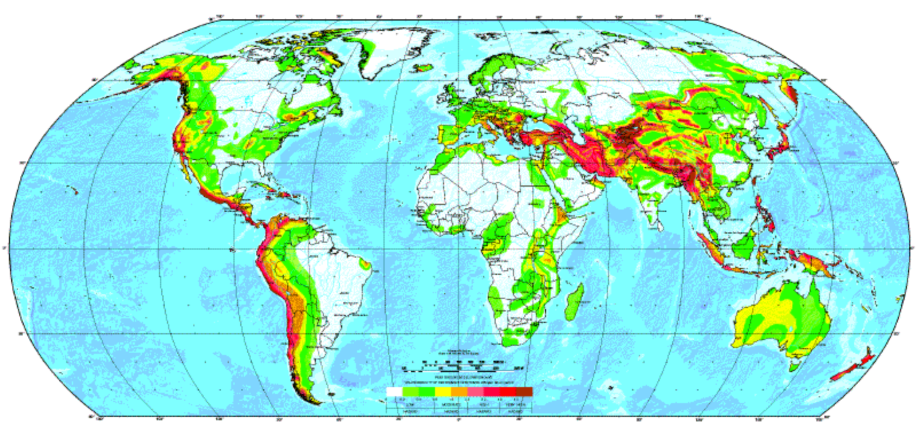
- Earthquake Risk of Tokyo Metropolitan
- Lessons from the 1995 Kobe Earthquake
- Earthquake Risk Reduction Technology
  Building Response Control
  Earthquake Information System

Natural Hazard Risk Index (Munich Re, 2005)

Natural Hazard Risk Index = Hazard × Vulnerability × Exposure

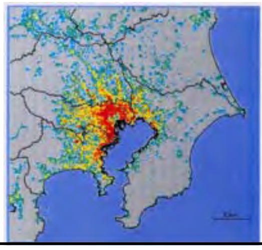
Hazard

Japan is one of the most earthquake-prone countries.

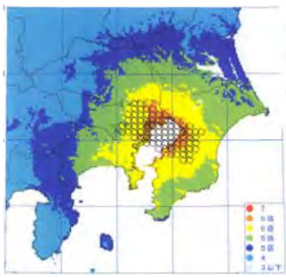


Exposure of Tokyo Metropolitan

	Population	Wooden Houses	Buildings
Tokyo	12,700,000	1,800,000	1,900,000
Kanagawa	8,900,000	1,600,000	880,000
Saitama	7,100,000	1,600,000	510,000
Chiba	6,100,000	1,400,000	400,000
Total	34,800,000	6,400,000	3,700,000



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

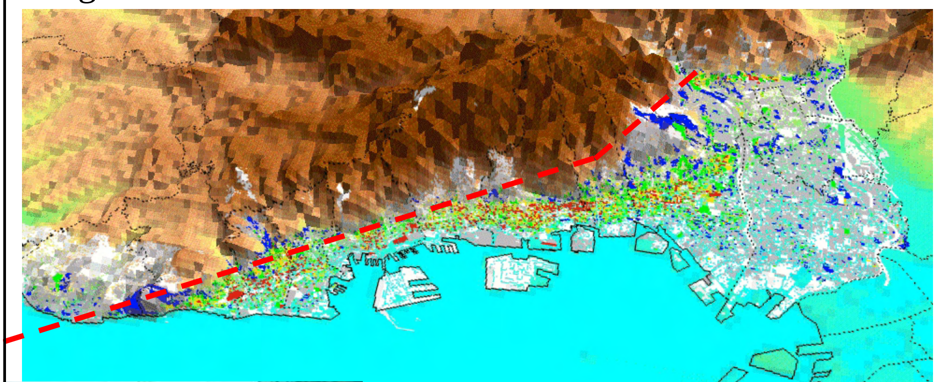
Effects of Interruption of Transportation $50billion

Total Loss $940billion

Lessons from the 1995 Kobe earthquake

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

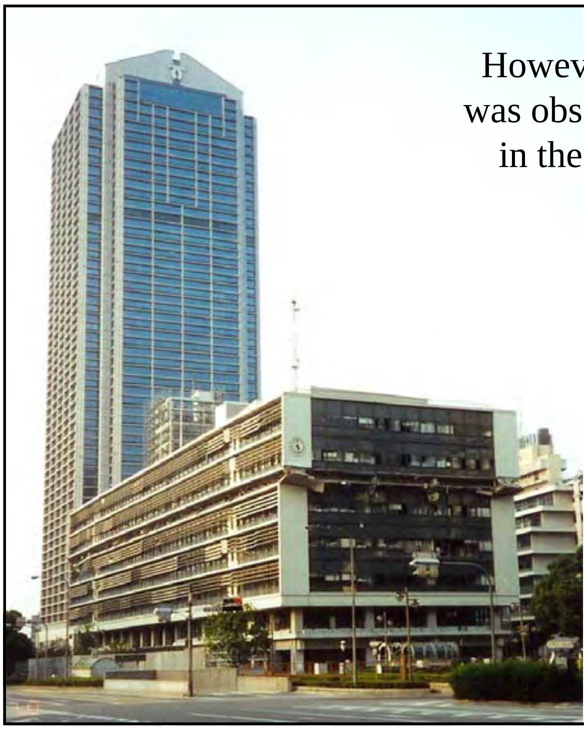
Catastrophic damage was observed in the disastrous belt zone along the fault.



Most of casualties were caused by collapse of buildings and overturning of building contents.

Collapsed 2-story wooden house

Scattering building contents



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

Kobe City Hall

Reinforced Concrete Buildings (after Obayashi Corp.)

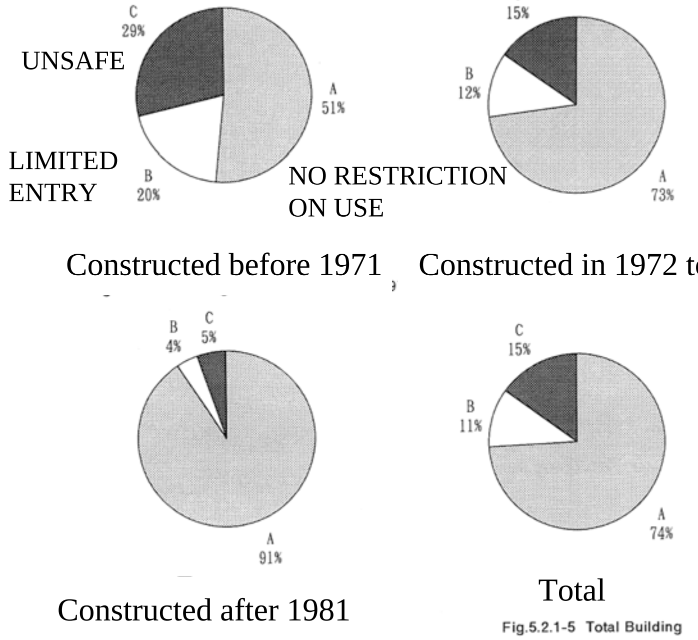


Fig.5.2.1-5 Total Building

Information

Asahi Evening News

Tuesday, January 17, 1995

TEMBLOR'S TOLL PASSES 200

Twenty-four Socialist rebels to form Diet voting bloc

- 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

E-defense
(Largest Shaking Table in the World)

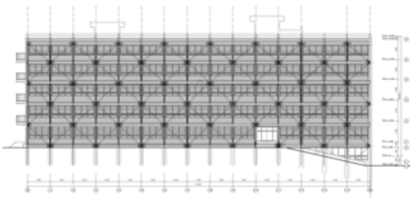
Completed on Jan., 2005,
Construction Period: 5 years, Construction Cost: 400 million $

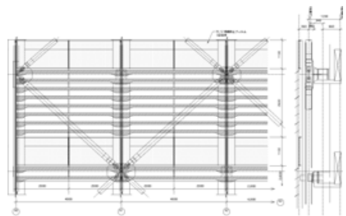
Items	Specifications	
Max. Capacity	1,200ton	
Table Size	20m×15m	
Drive System	Oil Accumulator	
Direction	Horizontal	Vertical
Peak Acc.	900cm/s^{2}以上	1,500cm/s^{2}以上
Peak Vel.	200cm/s	70cm/s
Peak Disp.	±100cm	±50cm

Examples of Seismic Retrofit of Buildings

Design Conscious Seismic Retrofit

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

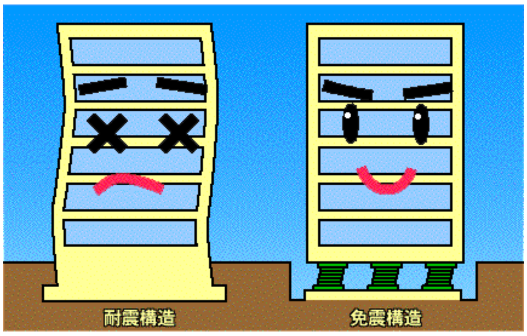




Building Reform and Renovation Award

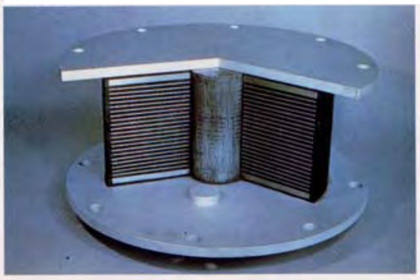
Takeuchi Laboratory

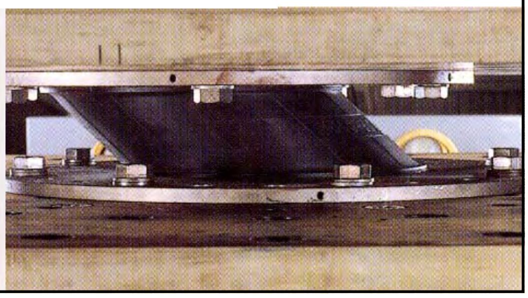
Base-Isolation System



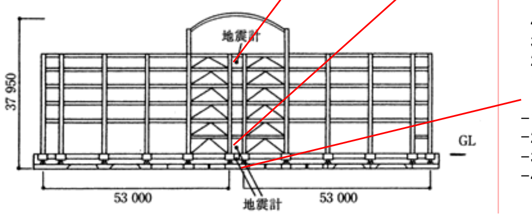
after JSSI

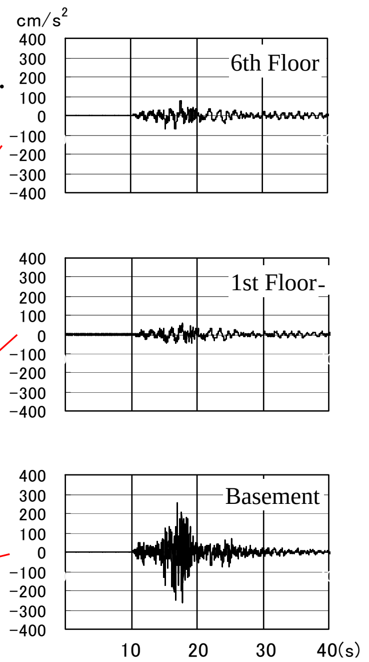
Rubber Bearing laminated by rubber and steel sheets





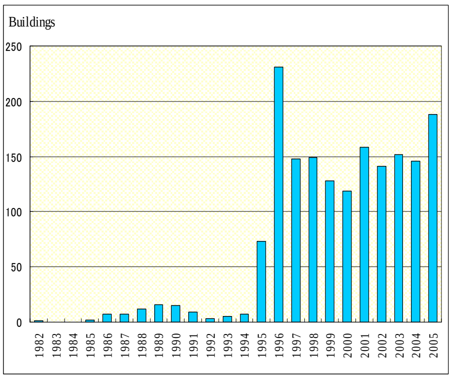
The WEST building located about 15km north of the fault of the Kobe earthquake.





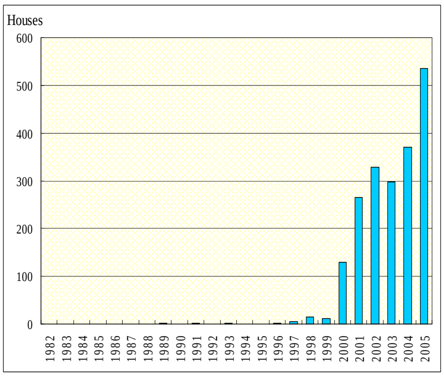
Acceleration Time Histories (NS comp.)

Total Number is about 2000



Number of Base-Isolated Buildings

Total Number is about 2000



Number of Base-Isolated Houses

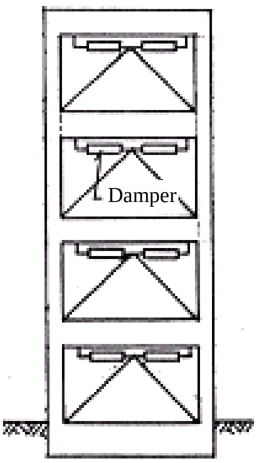
Base-Isolated Town

21 Buildings on Base-Isolated Ground of 15,000 m^2 with 242 Rubber Bearings and Sliders

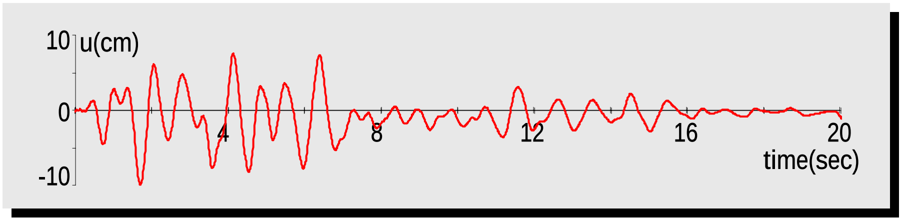
Seismic Retrofit
by Isolation System

Structural Response Control System

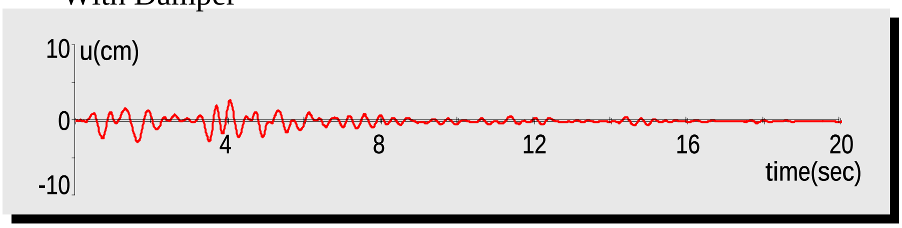
4000 buildings



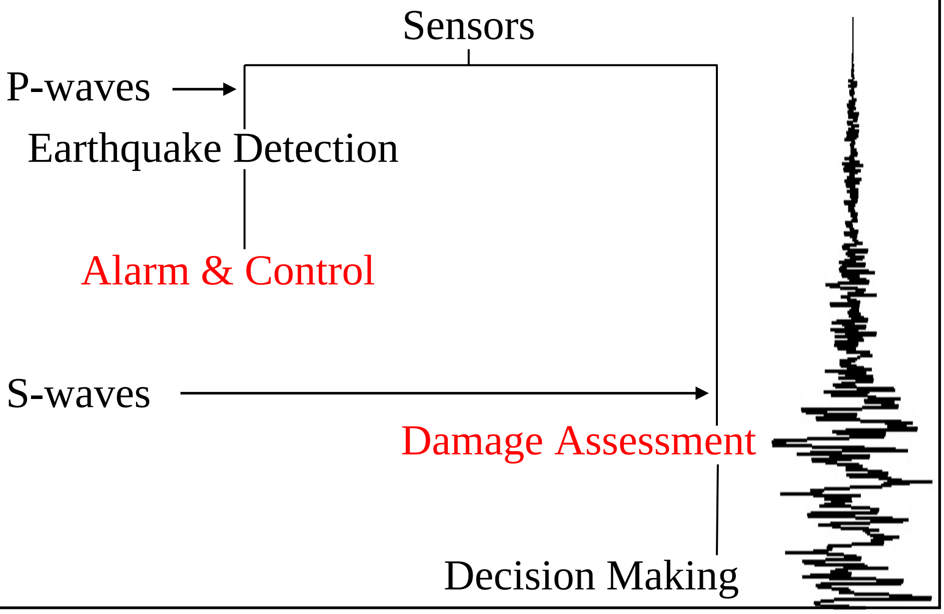
Without Damper



With Damper



Earthquake Information System



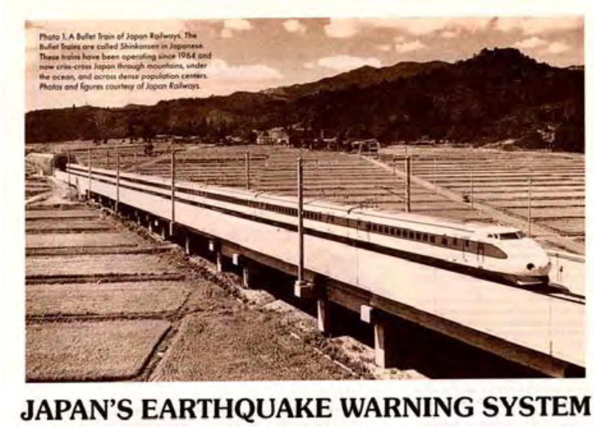
Pioneer of Earthquake Alarm System UrEDAS

(Urgent Earthquake Detection and Alarm System)

The project was started in 1975.

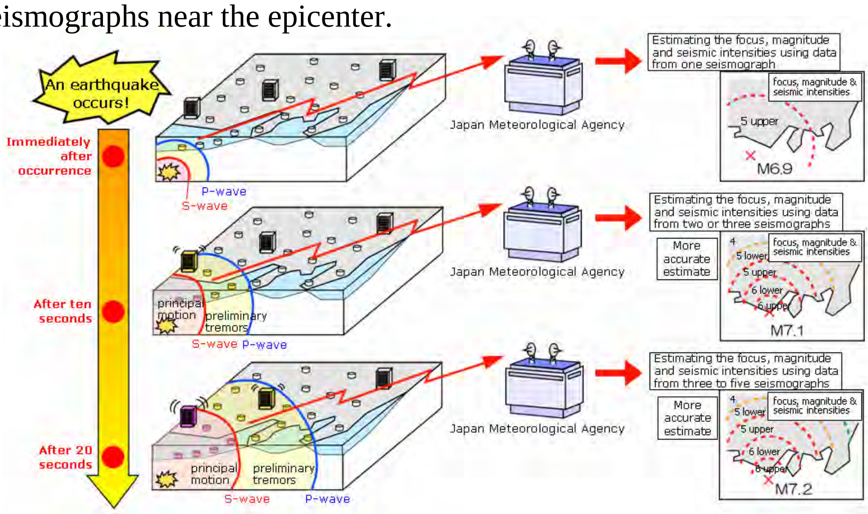
The prototype was developed in 1983.

The operation for the Bullet Train was started in 1990.

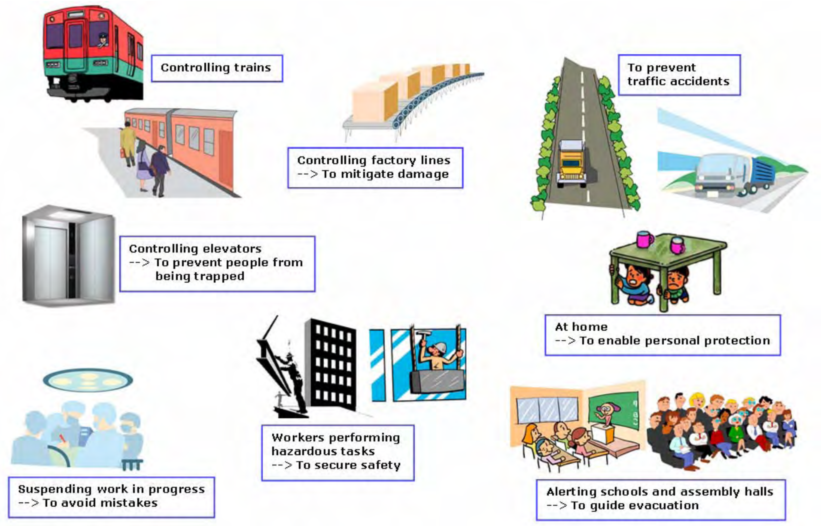


EARTHQUAKE EARLY WARNING SYSTEM BY JMA

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.



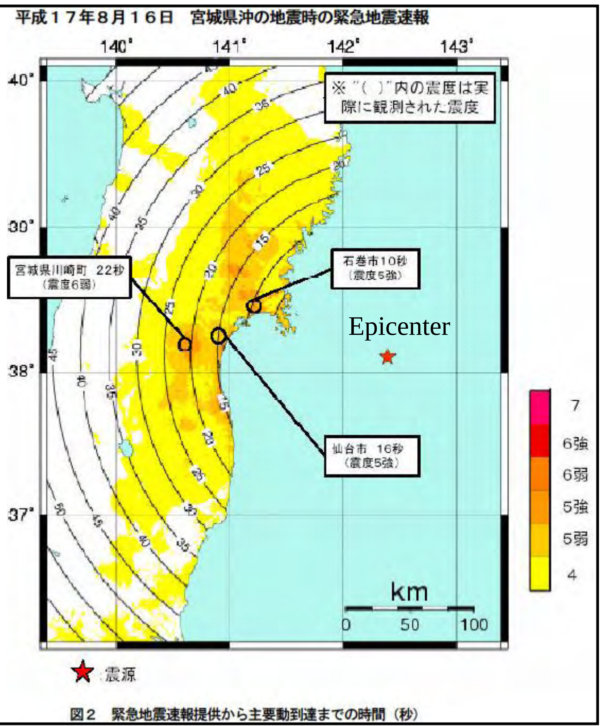
The Earthquake Early Warning is aimed at mitigating earthquake-related damage by allowing countermeasures such as promptly slowing down trains, controlling elevators to avoid danger and enabling people to quickly protect themselves in various environments such as factories, offices, houses and near cliffs.



Example of Prompt Earthquake Information

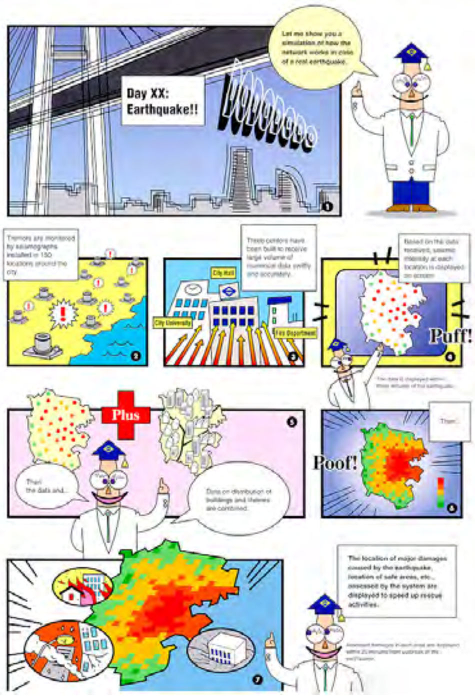
緊急地震速報 来る前に知る

緊急地震速報 来る前に知る



Real-Time Damage Assessment

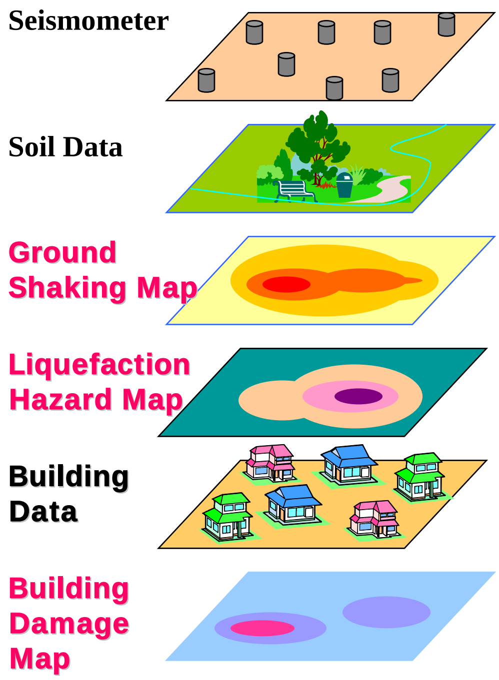
Based on monitoring of ground shaking, locations of damage areas and safer areas are assessed in real-time for speedy and adequate emergency response activities.



Flow of Seismic Hazard and Risk Assessment

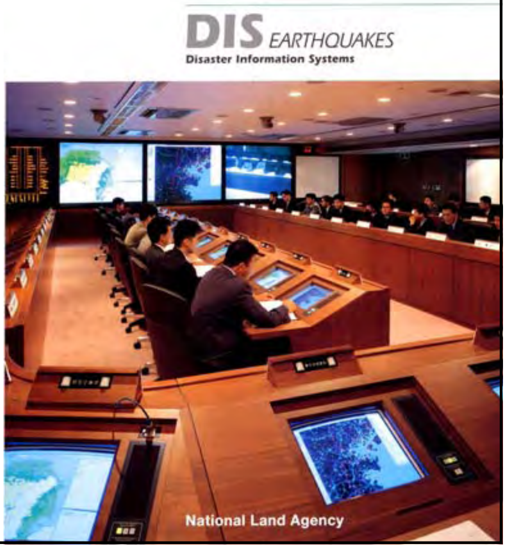
Ground Shaking Map and Liquefaction Map are evaluated from ground motion data together with soil data.

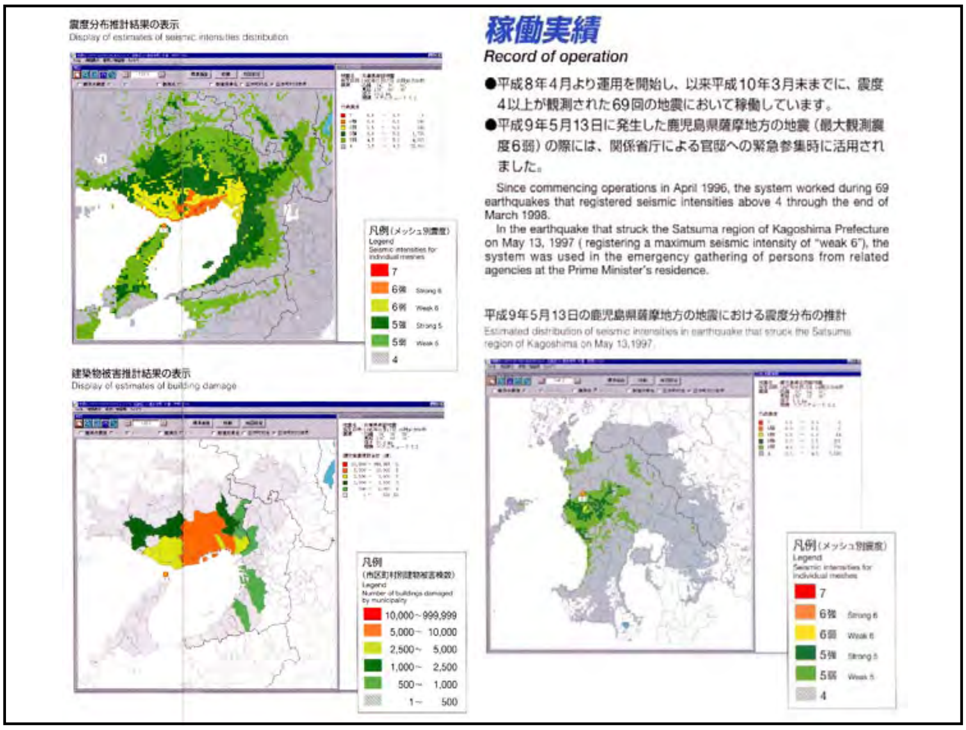
Building Damage Map is evaluated from building data and ground shaking map.



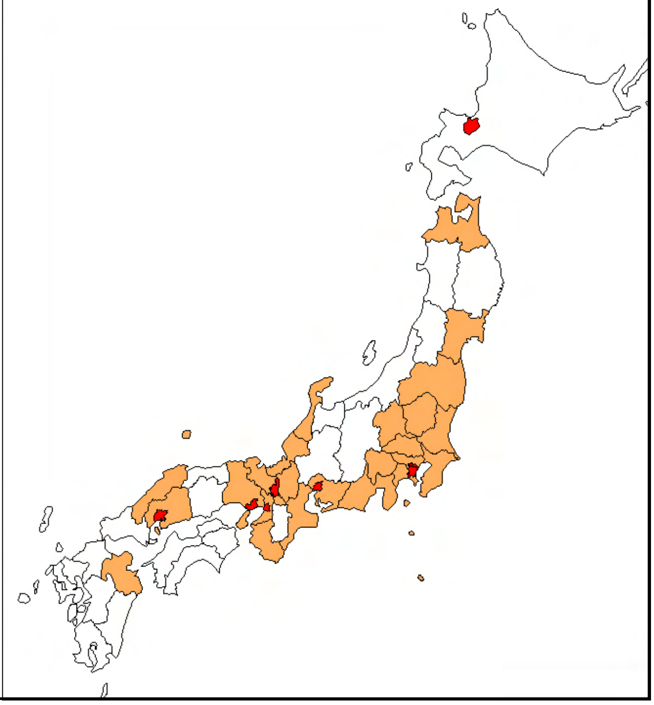
Disaster Information System by Central Government

In 1996, the National Land Agency was developed the nation-wide 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.