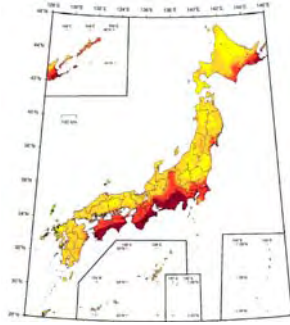
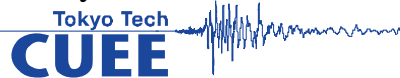


# Earthquake Risk and Its Reduction Technology in Japan



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



## Agenda

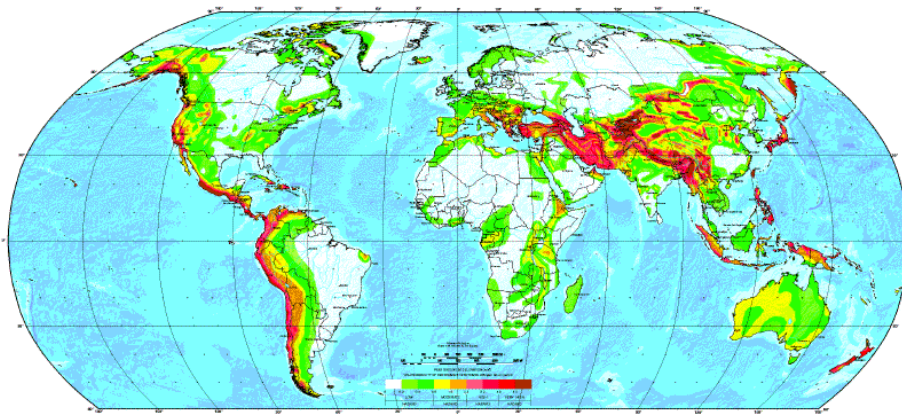
- Earthquake Risk of Tokyo Metropolitan
- Lessons from the 1995 Kobe Earthquake
- Earthquake Risk Reduction Technology
  - Building Response Control
  - Earthquake Information System

## Natural Hazard Risk Index (Munich Re, 2005)



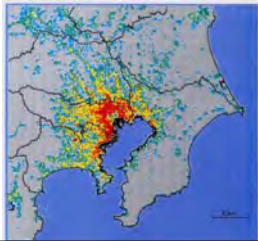
## Hazard

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,

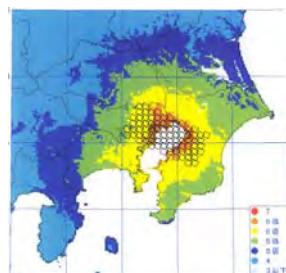
Infrastructures \$90billion

Indirect Loss \$380billion

Decrease in Products \$330billion

Effects of Interruption of Transportation \$50billion

Total Loss \$940billion

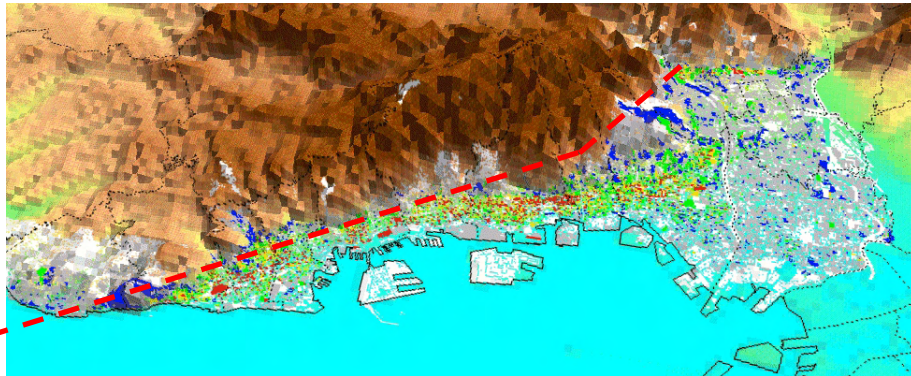


# Lessons from the 1995 Kobe earthquake

Dead 6,400  
Injured 40,000  
Damaged Buildings 250,000  
Direct Monetary Loss \$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.



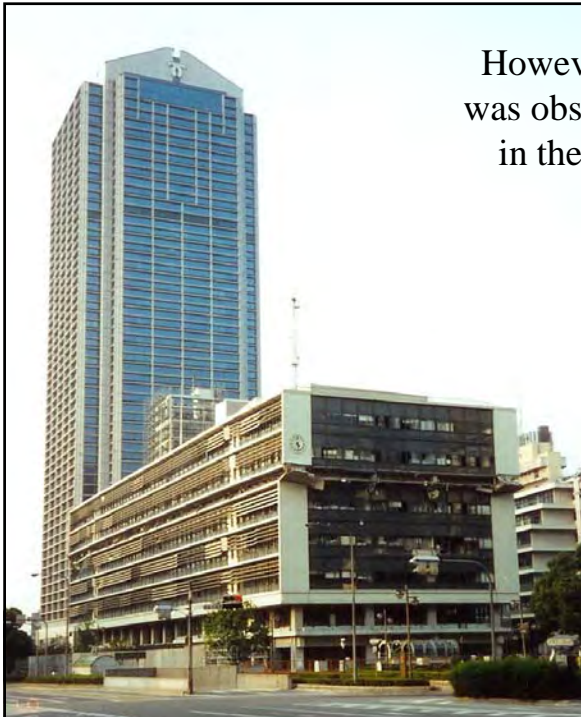
Collapsed 2-story wooden house



Scattering building contents

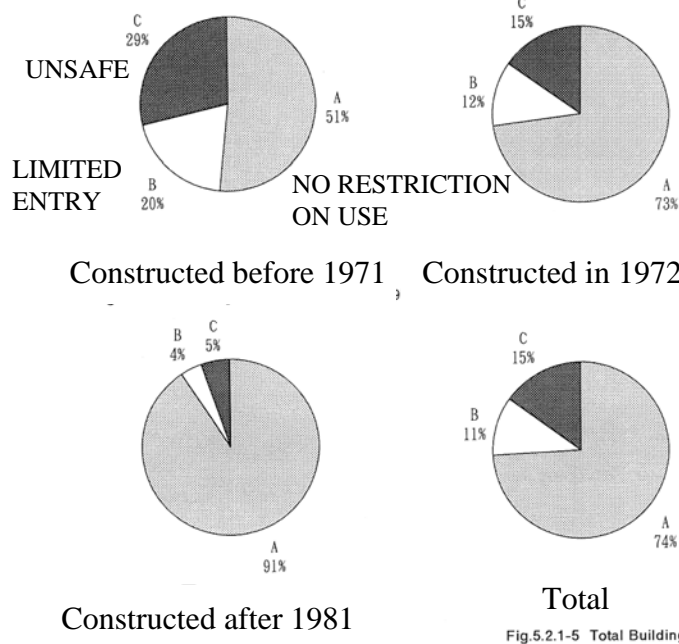


However, no severe damage was observed at new buildings in the disastrous belt zone.



Kobe City Hall

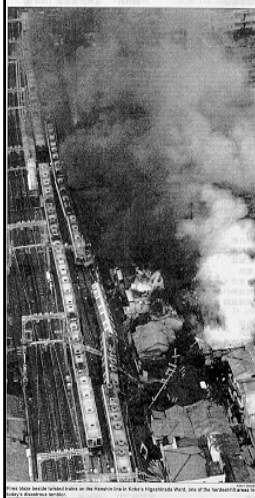
## Reinforced Concrete Buildings (after Obayashi Corp.)



## Information

**Asahi Evening News**  
Tuesday, January 17, 1995

### TEMBLOR'S TOLL PASSES 200



The powerful earthquake leveled buildings, crumpled highways and twisted rail lines this morning. The death toll and damage estimates continue to rise.

The toll from the quake is expected to reach 200 by the end of the day, according to the state's Department of Transportation. The state's Department of Transportation said that the quake caused the collapse of Interstate 5, one of the state's major highways. The collapse of the highway caused a major traffic jam and forced thousands of people to seek shelter in nearby schools and community centers.

The quake also caused the collapse of several buildings in the Los Angeles area. The collapse of the buildings caused the death of several people and injured many others. The state's Department of Transportation said that the quake caused the collapse of several buildings in the Los Angeles area. The collapse of the buildings caused the death of several people and injured many others.

Twenty-four Socialist rebels to form Diet voting bloc

The defections put a major split in the Socialist Democratic Party of Japan, although Prime Minister Murayama's coalition government is not endangered.

Asahi Evening News

- 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 \$



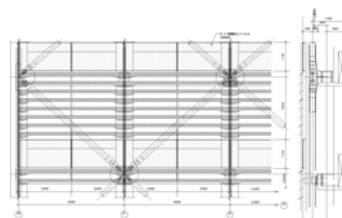
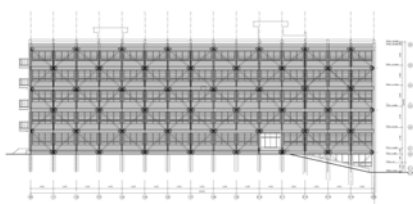
Items	Specifications	
Max. Capacity	1,200ton	
Table Size	20m×15m	
Drive System	Oil Accumulator	
Direction	Horizontal	Vertical
Peak Acc.	900cm/s <sup>2</sup> 以上	1,500cm/s <sup>2</sup> 以上
Peak Vel.	200cm/s	70cm/s
Peak Disp.	±100cm	±50cm

## Examples of Seismic Retrofit of Buildings



## Design Conscious Seismic Retrofit

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

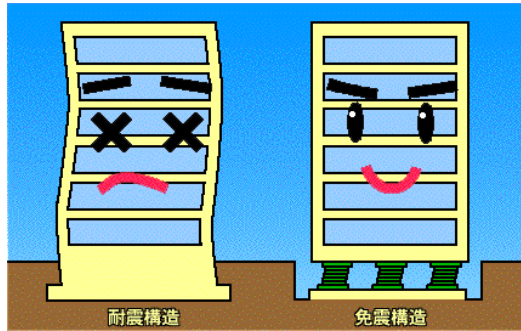


Building Reform and Renovation Award

Takeuchi Laboratory

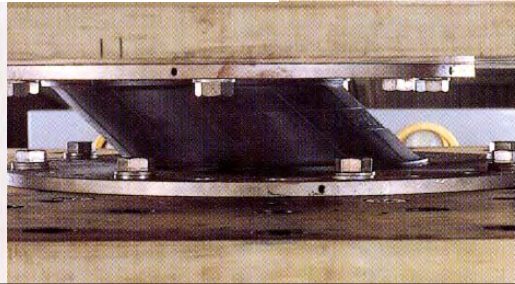
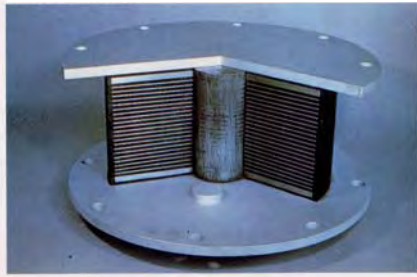


# Base-Isolation System

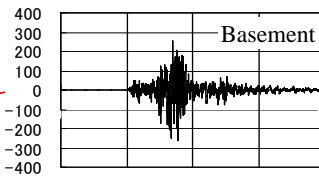
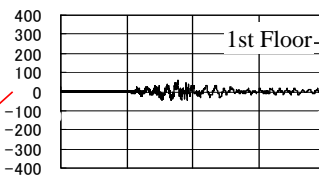
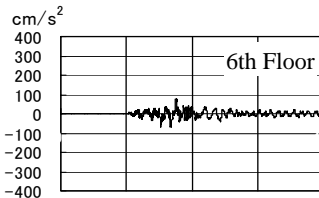
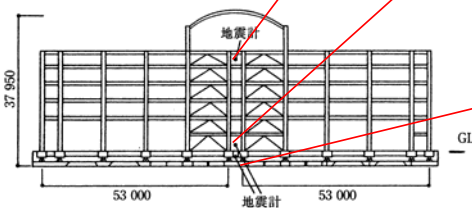


after JSSI

Rubber Bearing laminated by rubber and steel sheets

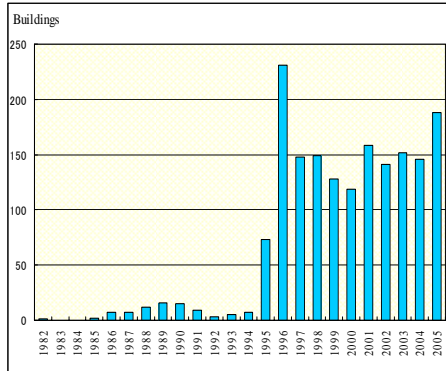


The WEST building located about 15km north of the fault of the Kobe earthquake.

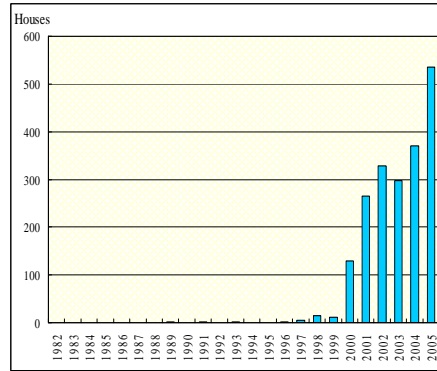


Acceleration Time Histories (NS comp.)

Total Number is about 2000



Total Number is about 2000



Number of Base-Isolated Buildings

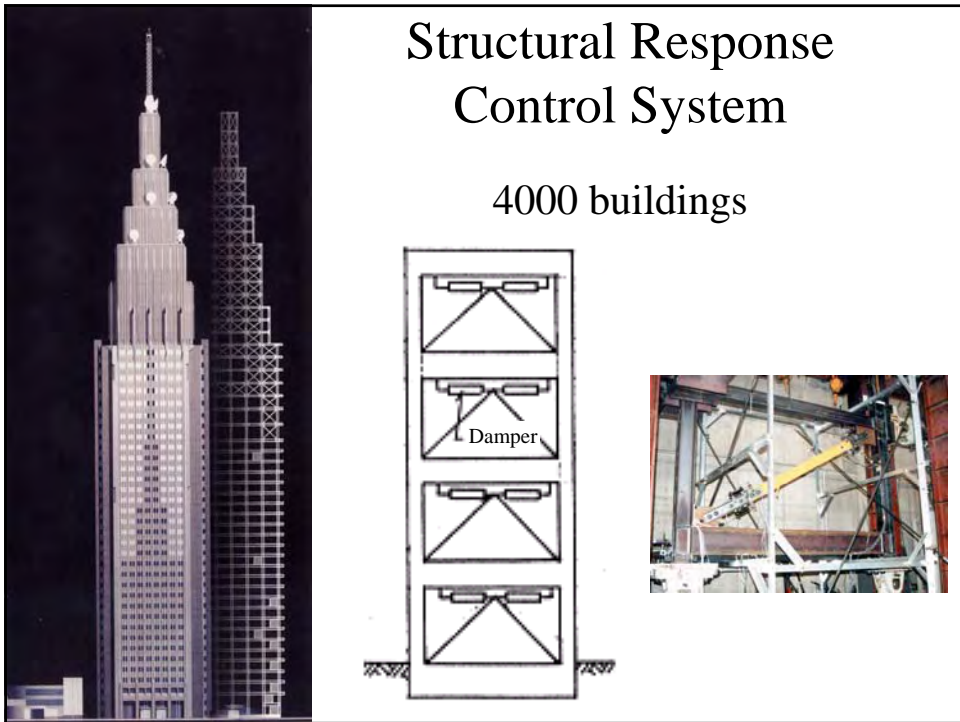
Number of Base-Isolated Houses

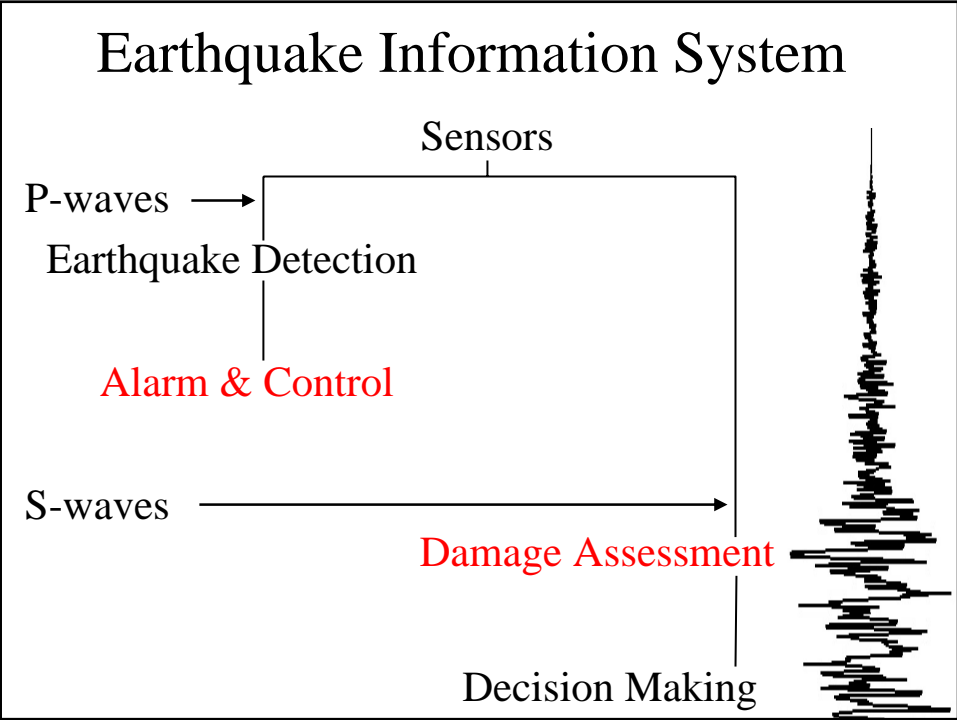
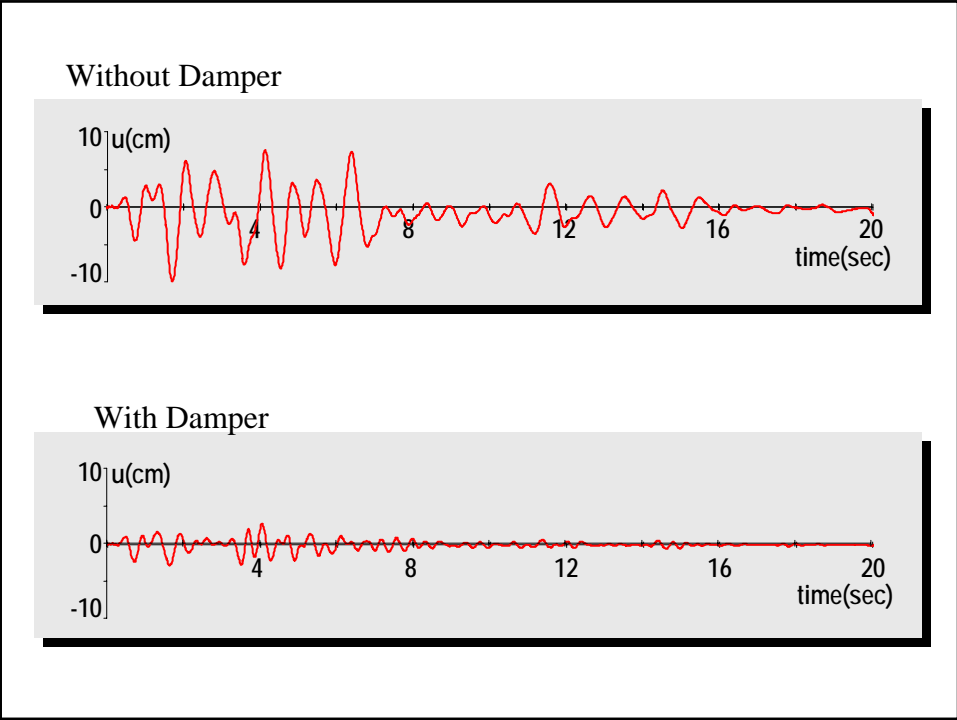
### Base-Isolated Town



21 Buildings on Base-Isolated Ground of 15,000 m<sup>2</sup> with 242 Rubber Bearings and Sliders







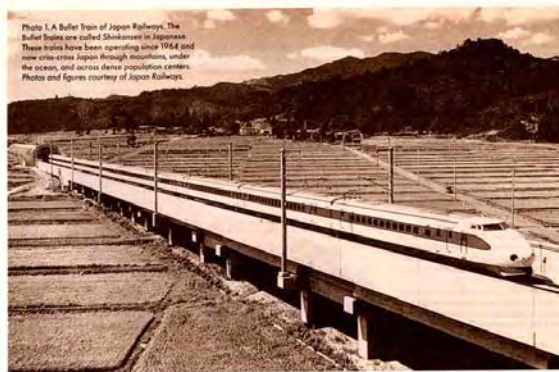
# Pioneer of Earthquake Alarm System UrEDAS

(Urgent Earthquake Detection and Alarm System)

The project was started in 1975.

The prototype was developed in 1983.

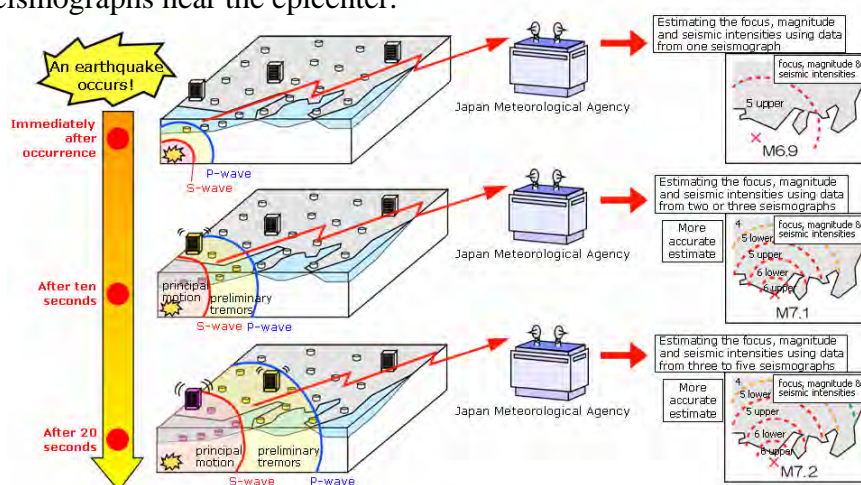
The operation for the Bullet Train was started in 1990.



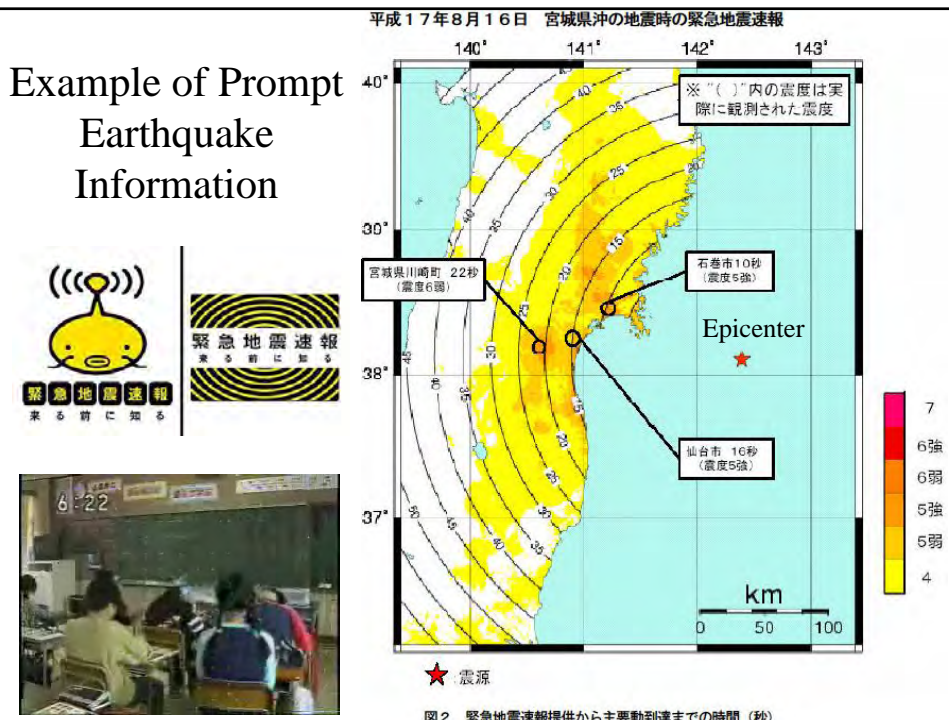
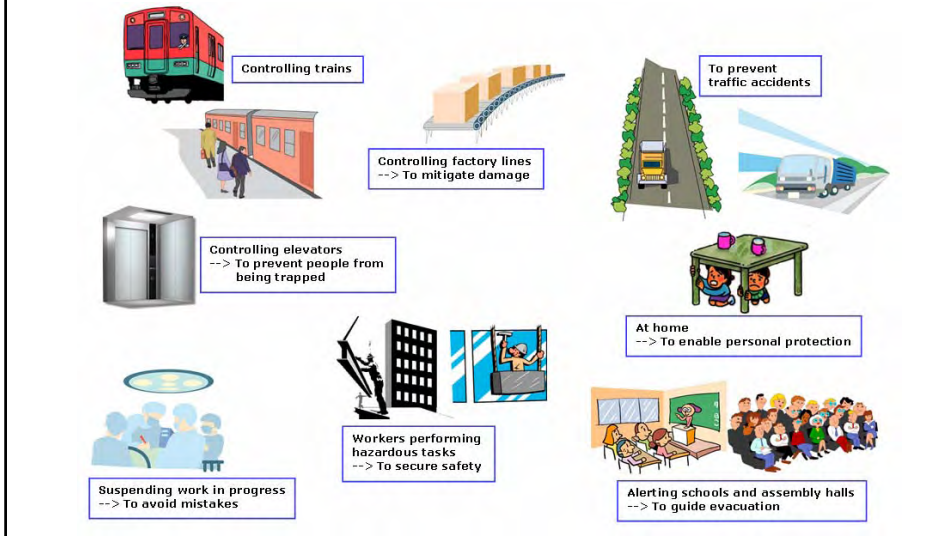
JAPAN'S EARTHQUAKE WARNING SYSTEM

## 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.

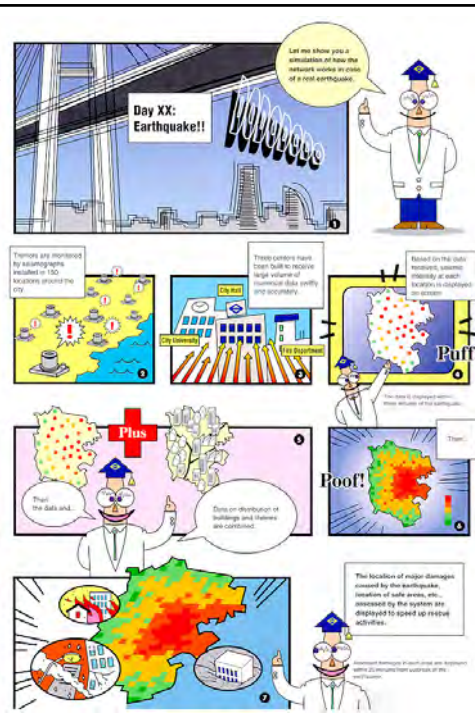


The Earthquake Early Warning is aimed at mitigating earthquake-related damage by allowing countermeasures such as promptly slowing down trains, controlling elevators to avoid danger and enabling people to quickly protect themselves in various environments such as factories, offices, houses and near cliffs.



# Real-Time Damage Assessment

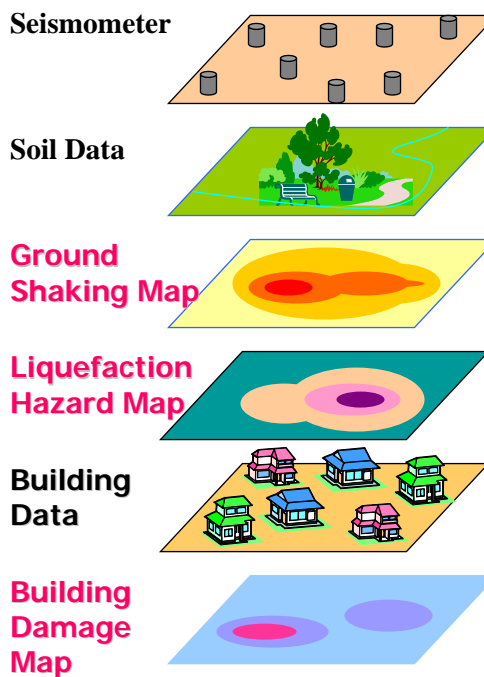
Based on monitoring of ground shaking, locations of damage areas and safer areas are assessed in real-time for speedy and adequate emergency response activities.



# Flow of Seismic Hazard and Risk Assessment

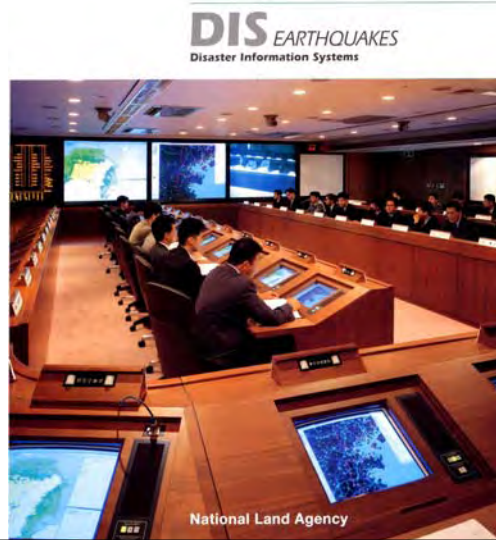
**Ground Shaking Map and Liquefaction Map** are evaluated from ground motion data together with soil data.

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



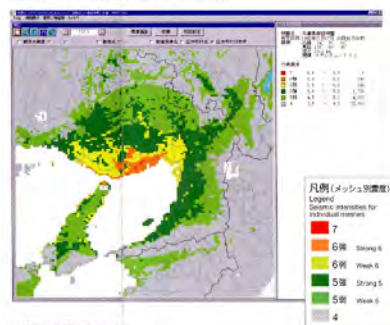
# Disaster Information System by Central Government

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.

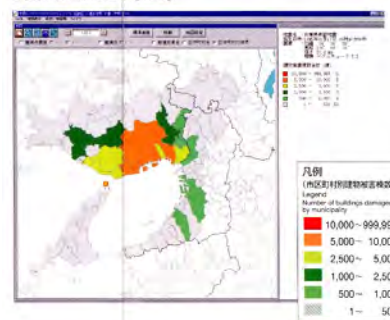


**DIS** EARTHQUAKES  
Disaster Information Systems

震度分布推計結果の表示  
Display of estimates of seismic intensities distribution



建築物被害推計結果の表示  
Display of estimates of building damage



## 稼働実績

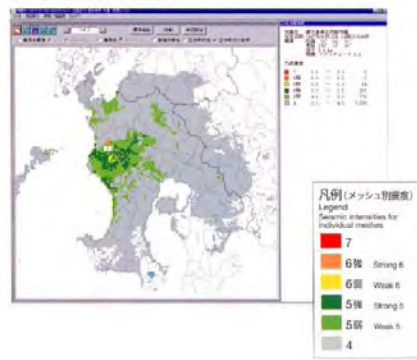
### Record of operation

- 平成8年4月より運用を開始し、以来平成10年3月末までに、震度4以上が観測された69回の地震において稼働しています。
- 平成9年5月13日に発生した鹿児島県薩摩地方の地震（最大観測震度6弱）の際には、関係省庁による官邸への緊急参集時に活用されました。

Since commencing operations in April 1996, the system worked during 69 earthquakes that registered seismic intensities above 4 through the end of March 1998.

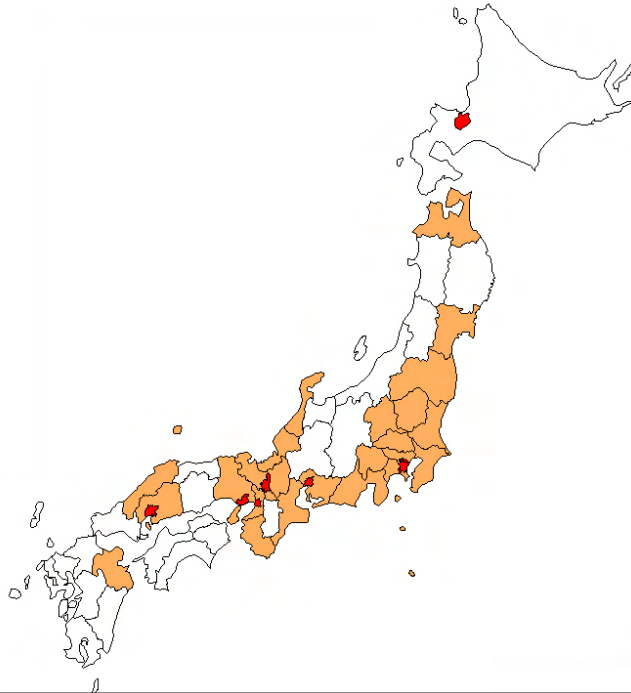
In the earthquake that struck the Satsuma region of Kagoshima Prefecture on May 13, 1997 (registering a maximum seismic intensity of "weak 6"), the system was used in the emergency gathering of persons from related agencies at the Prime Minister's residence.

平成9年5月13日の鹿児島県薩摩地方の地震における震度分布の推計  
Estimated distribution of seismic intensities in earthquake that struck the Satsuma region of Kagoshima on May 13, 1997.





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.