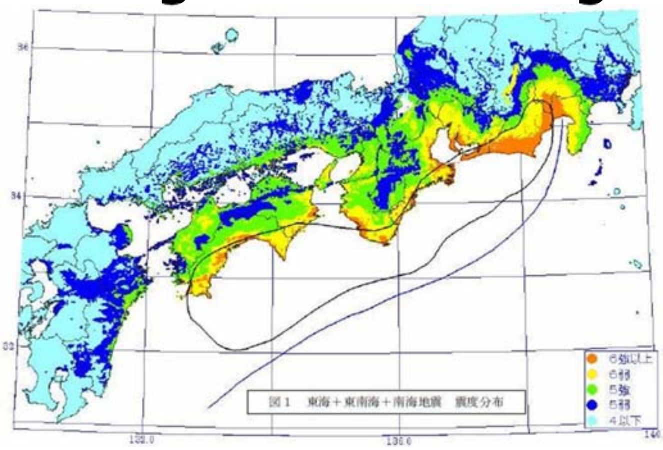
Effects of Long Period Ground Motion from Gigantic Earthquakes to High-rise Buildings



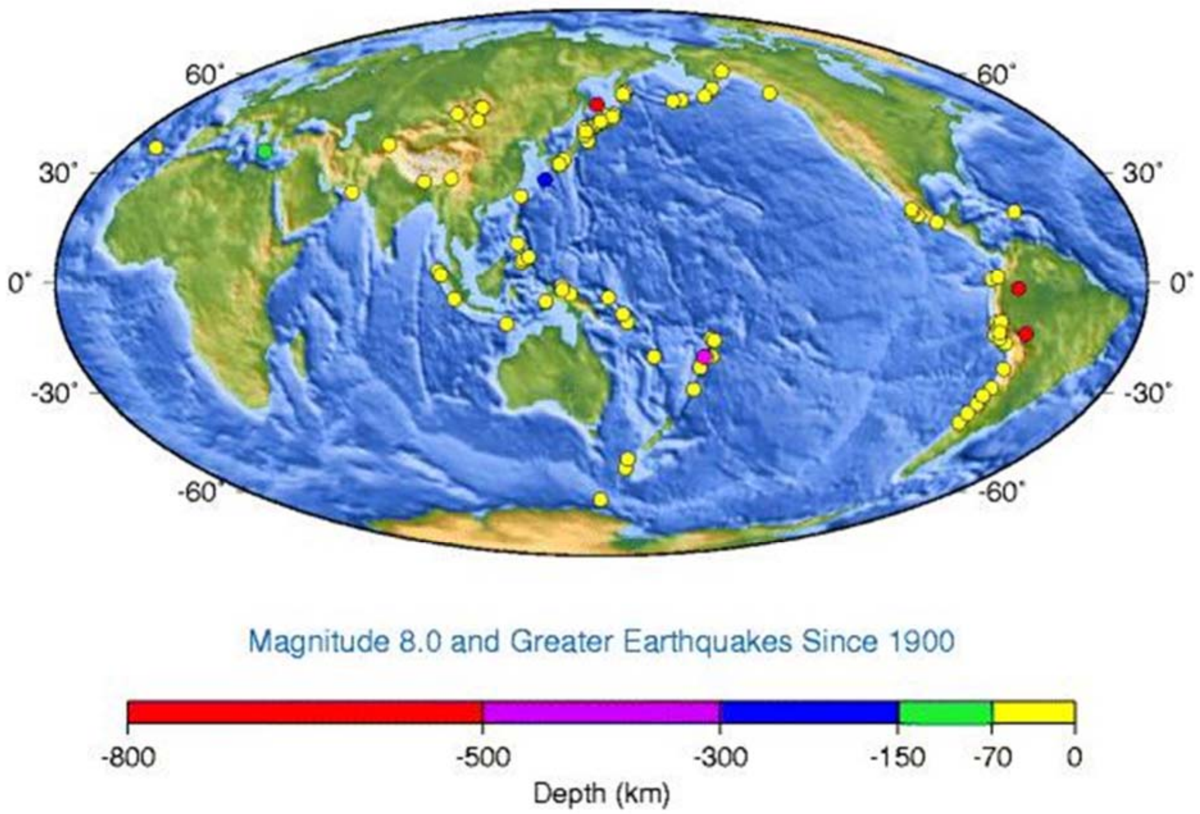
Prof. S. Midorikawa

Center for Urban Earthquake Engineering

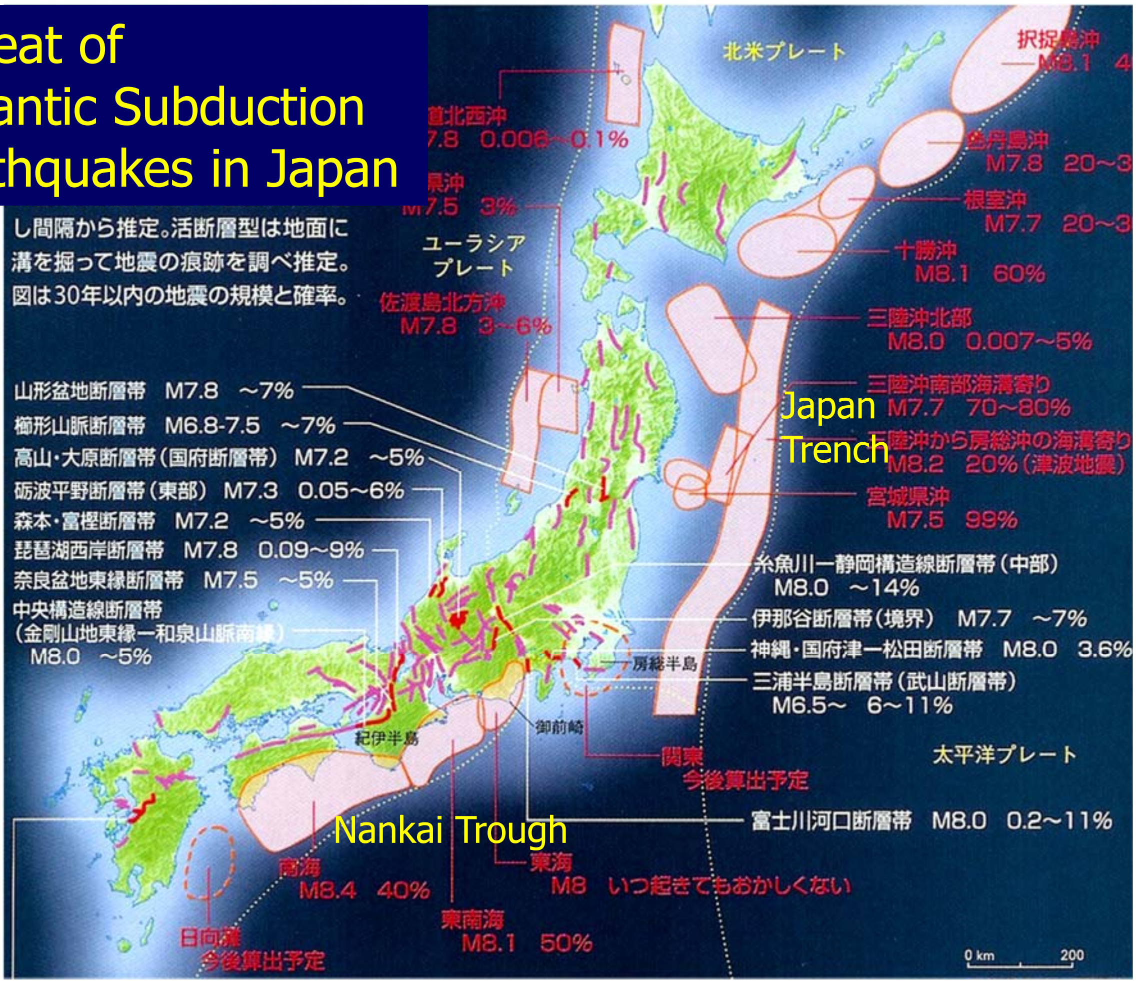
Tokyo Institute of Technology

Tokyo Tech CUEE

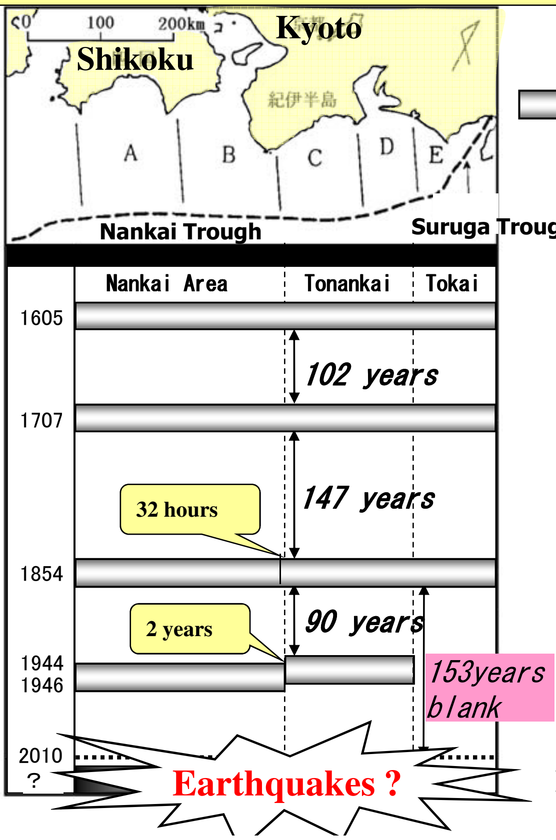
Japan has suffered gigantic subduction earthquakes as well as Peru and Chile.



Threat of Gigantic Subduction Earthquakes in Japan



Recurrence of Tokai, Tonankai, and Nankai Earthquakes



: Source Region of Earthquakes

1605 Keicho Earthquake (M7.9)

1707 Hoei Earthquake (M8.4)
Victim 5,038

1854 Ansei-Tokai Earthquake (M8.4)
Victim 2,658

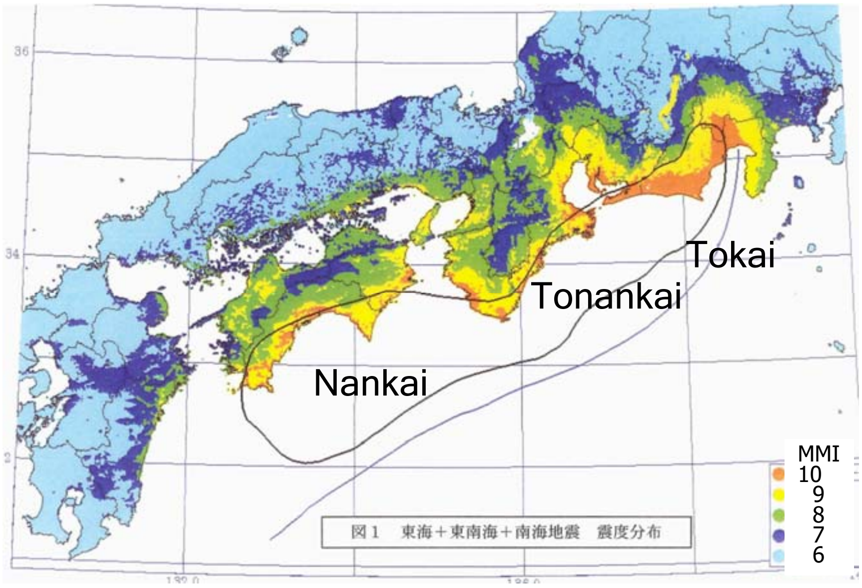
1944 Tonankai Earthquake (M7.9)
Victim 1,251

1946 Nankai Earthquake(M8.0)
Victim 1,330

Probability of Occurrence in 30 years is 50%.

Loss Estimation for Tokai-Tonankai-Nankai Earthquake by Central Disaster Management Council

Number of Fatality: 25,000
Heavily Damaged Houses: 550,000
Monetary loss: 1 trillion US$



Estimated Seismic Intensity Map

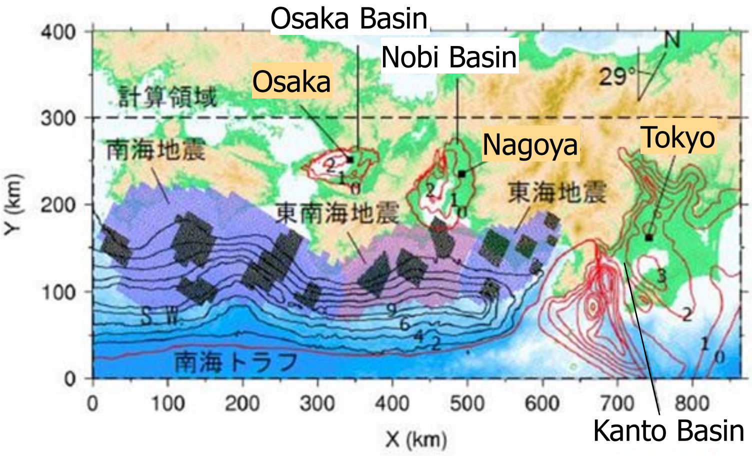
東海･東南海･南海地震同時発生時

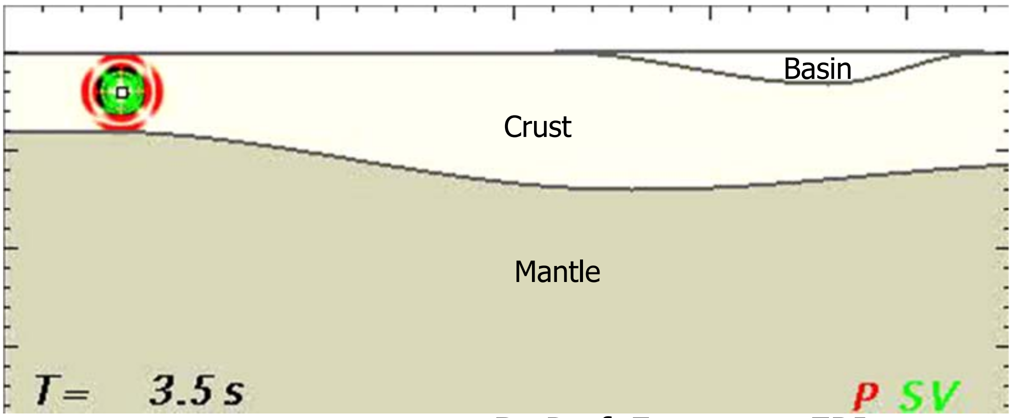
	死者数	全壊棟数
千葉	0	60
東京	0	40
神奈川	10	600
新潟	0	0
富山	0	0
石川	0	0
福井	0	30
山梨	200	5，100
長野	100	3，700
岐阜	30	3，900
静岡	8，100	230，000
愛知	1，900	91，000
三重	2，600	51，000
滋賀	10	1，200
京都	10	1，200
大阪	50	13，000
兵庫	100	6，100
奈良	10	1，400
和歌山	4，600	48，000
鳥取	0	0
島根	0	0
岡山	50	5，900
広島	30	4，000
山口	10	500
徳島	1，300	15，000
香川	0	1，700
愛媛	200	4，600
高知	4，900	55，000
福岡	0	20
佐賀	0	0
長崎	0	0
熊本	0	30
大分	30	1，200
宮崎	500	3，000
鹿児島	0	0
計	25，000	550，000

Anticipated Disaster

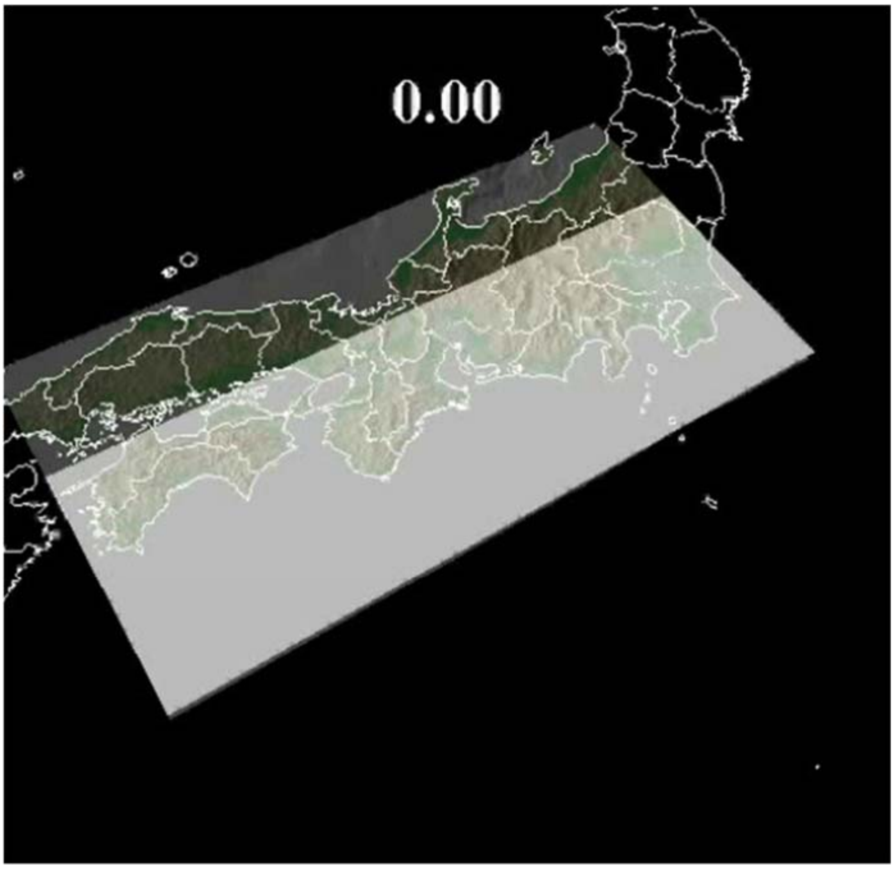
- Extensive Damage in Wide Area by Ground Shaking and Tsunami
- Effects of Long Period Ground Motion to Metropolitan Areas

Tokyo, Nagoya and Osaka Metropolitans are located on deep sedimentary basin.
The depth to bedrock is 2 or 3 km.
Basin-induced surface waves are easily excited in the metropolitans.





By Prof. Furumura, ERI



Yoshimura et al.(2010)

In metropolitan areas, number of high-rise buildings is rapidly increasing.

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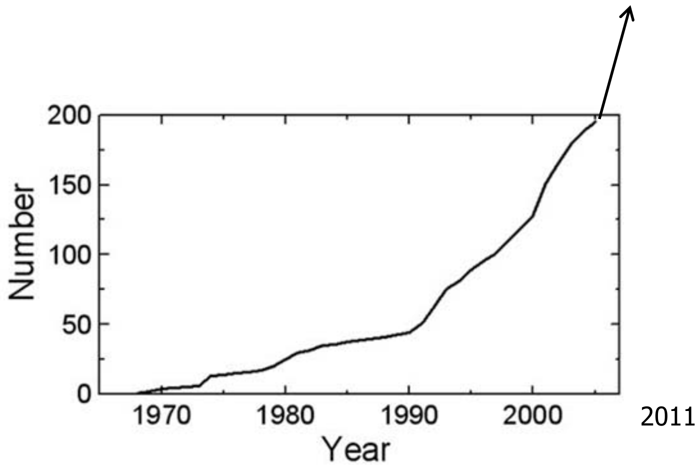
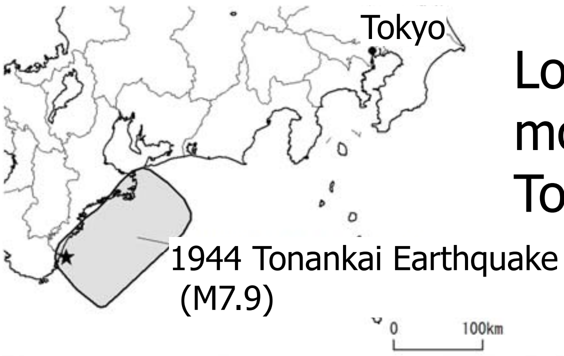
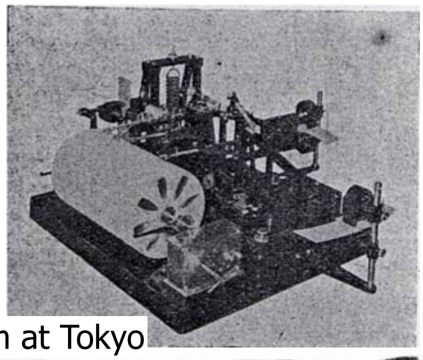
Potential risk by long period motion is increasing.



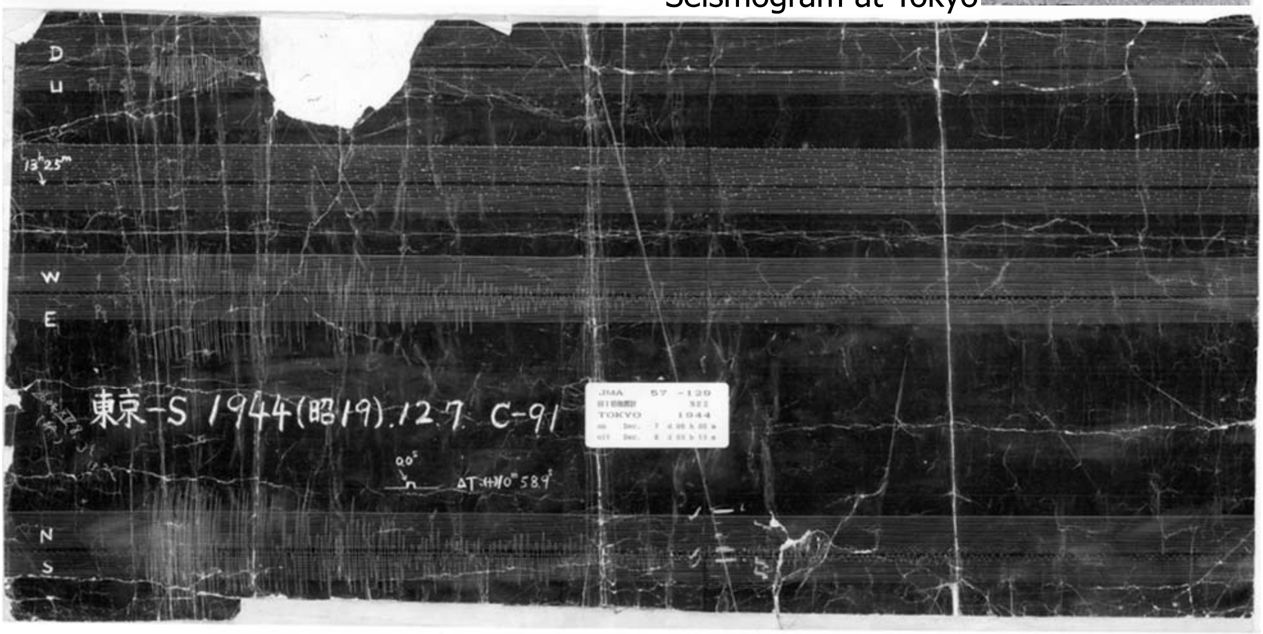
Accumulated Number of High-rise Buildings (20 storey or more) in Tokyo



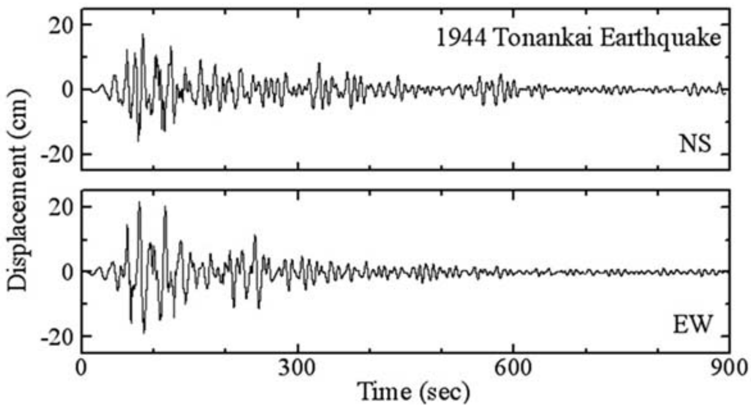
Long period motion in Tokyo



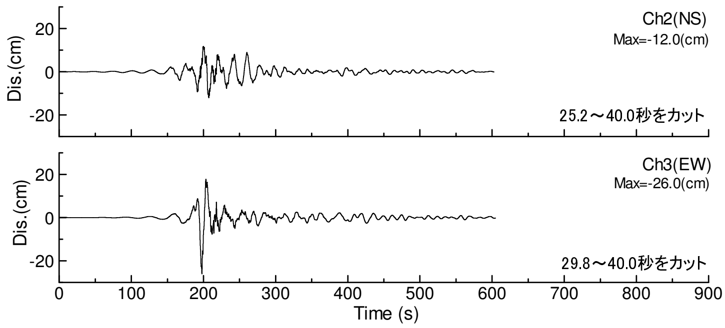
Seismogram at Tokyo

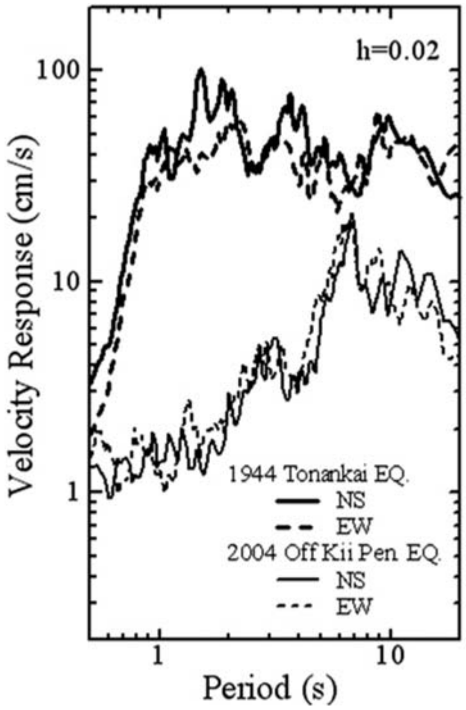


Tokyo (Deep Sediment Site), 1944 Tonankai Earthquake



Cerro El Roble (Rock Site), 2010 Chile Earthquake





Due to the anticipated M8 Tokai earthquake, the estimated response of a 40-story building in Tokyo is about 80 cm (Architectural Institute of Japan, 2006).

Although severe structural damage to high-rise buildings may not occur, the estimated response is large enough to frighten residents, displace building contents, and interrupt elevator operation.

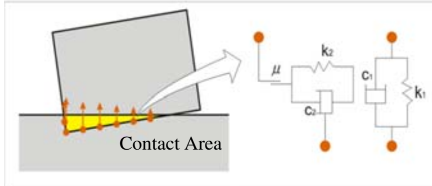



Effects to Building Contents

Shaking Table Test

Simulation

Determination of parameters used in simulation



Simulation of behavior of building contents due to the anticipated gigantic earthquakes (Tokyo, Nagoya, Osaka)

A Chest with Casters

Largely displaced by long period motion

A Desk with a Chair

A desk pushed by a chair rotated and displaced.

Behavior of Office Furniture due to Long Period Shaking

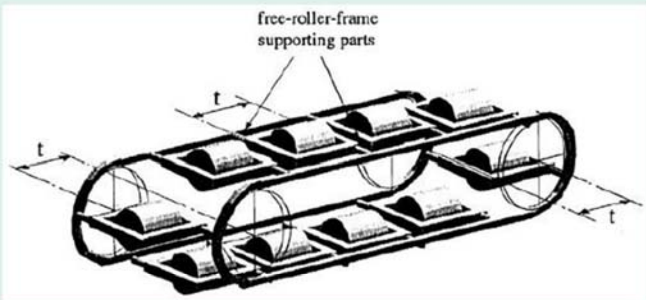
Desks and cabinets continue to move around and collide against each other for long duration. The behavior of the furniture can cause fear and injury to people in the floor, and make the evacuation action difficult.

Behavior of Kitchen Furniture due to Long Period Shaking

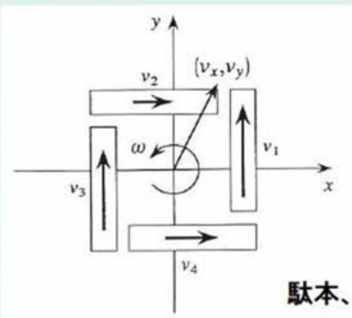
Video taken at a hotel in Valdivia during the 2010 Chile earthquake

How is feeling of long period ground motion ?
Because we have never experience it.

Development of Earthquake Simulator
To Provide Experience of Long-period Ground Motion



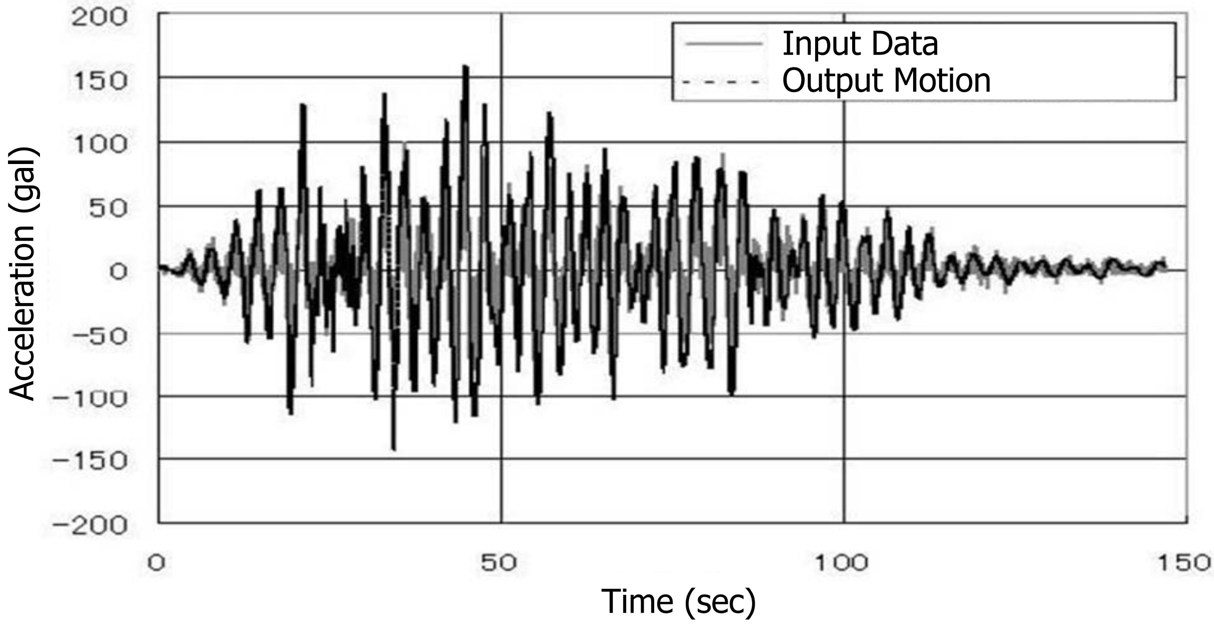
Mechanism of Vuton Crawler



$$\begin{bmatrix} v_1 \\ v_2 \\ v_3 \\ v_4 \end{bmatrix} = \begin{bmatrix} 0 & 1 & r_0 \\ -1 & 0 & r_0 \\ 0 & -1 & r_0 \\ 1 & 0 & r_0 \end{bmatrix} \begin{bmatrix} v_x \\ v_y \\ \omega \end{bmatrix}$$

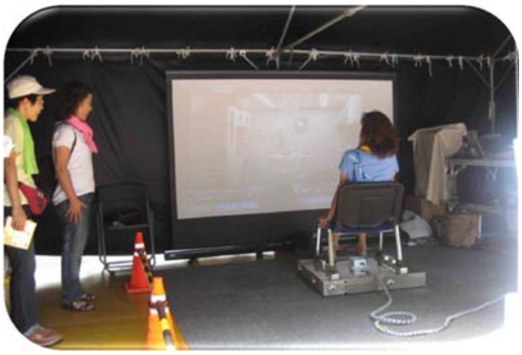
駄本、Cheng、広瀬(2001)より

Max. Velocity 1.3m/s



Experience of Long Period Motion by Earthquake Simulator

Demonstration at Disaster Reduction Fairs



Community Event

Kids Event

Event for Younger People

Event for Researchers

Awareness and Understanding of
Risk by Long Period Motion

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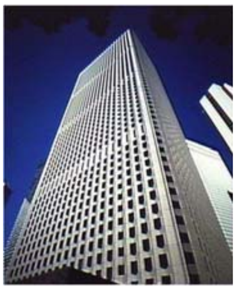
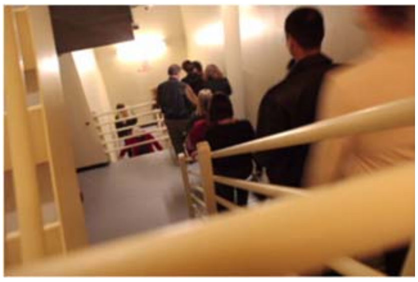
Planning and Enactment of Countermeasures

1. Fixing building contents,
2. Reducing building response by damping devices,
3. Early earthquake warning system,
4. Development of higher seismic resistant elevator,
5. Preparation of a manual for emergency response, and
6. Implementation of earthquake drill.





Thank you for your attention