



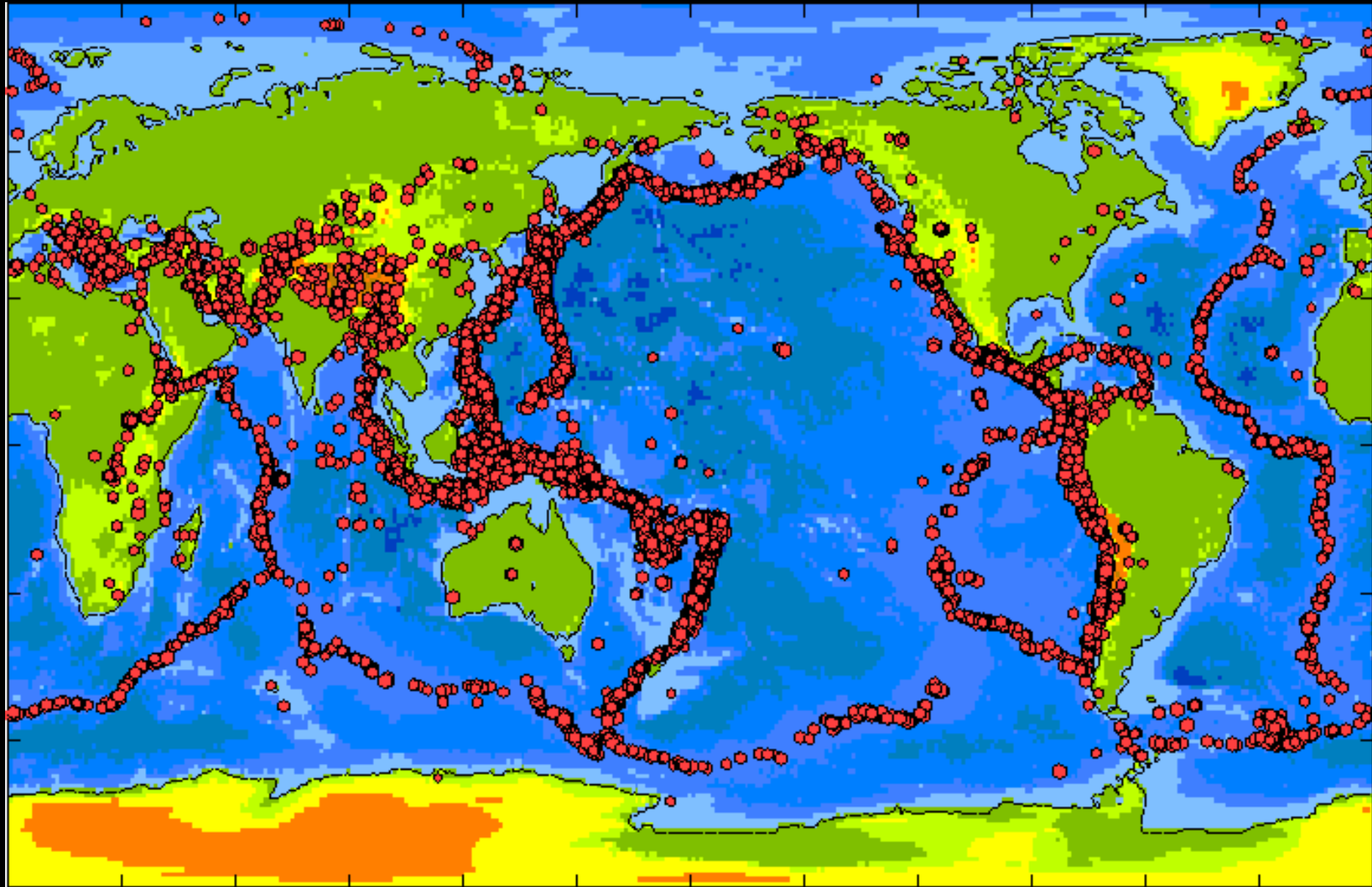
*How safe are our buildings and structures
against earthquakes and winds ?*

*Dr. Pennung Warnitchai
Asian Institute of Technology*

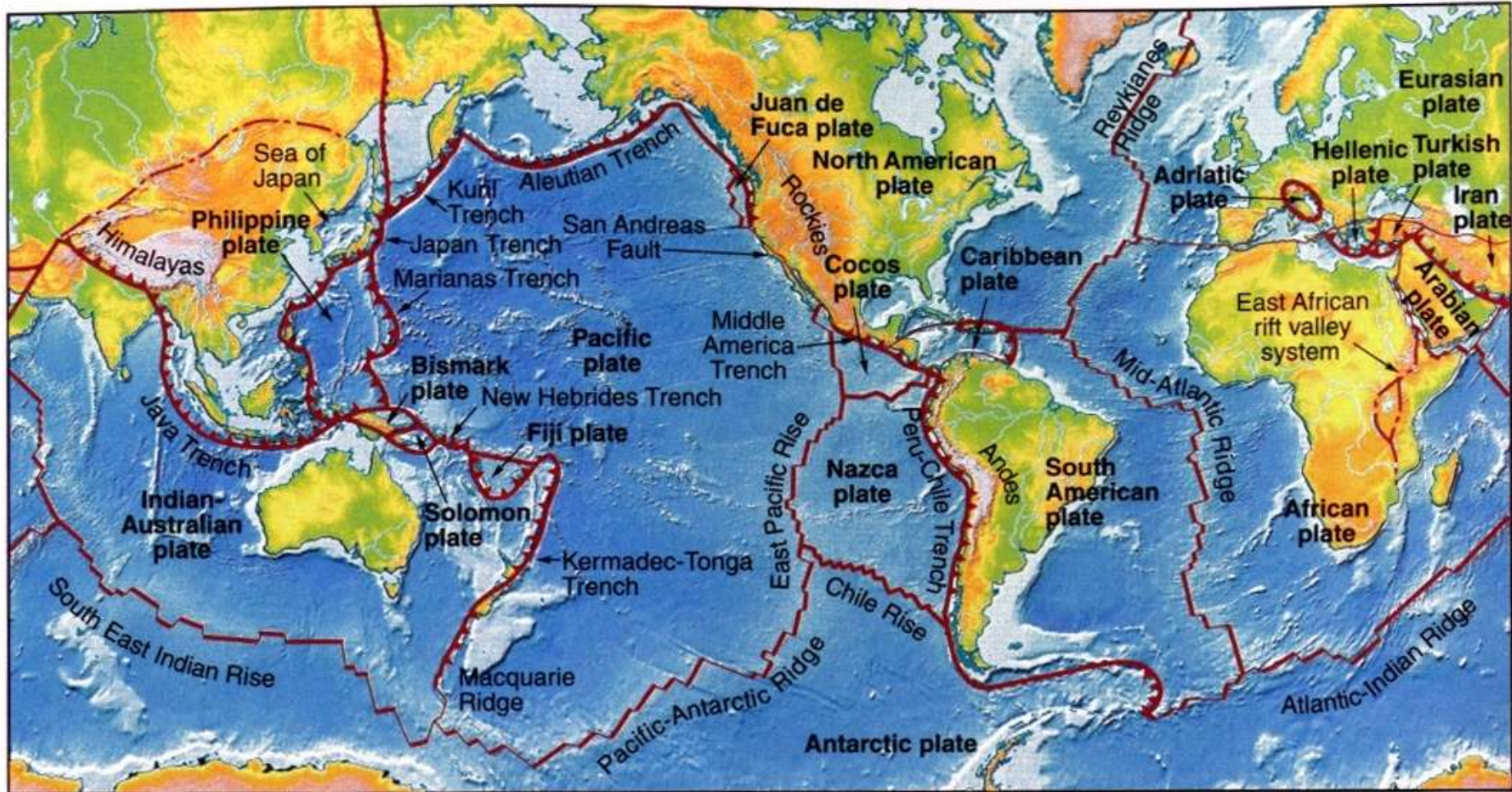
Where do earthquakes occur ?



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Tectonic Plates



Ridge axis
divergent boundary

Transform

Subduction zone
Convergent boundary

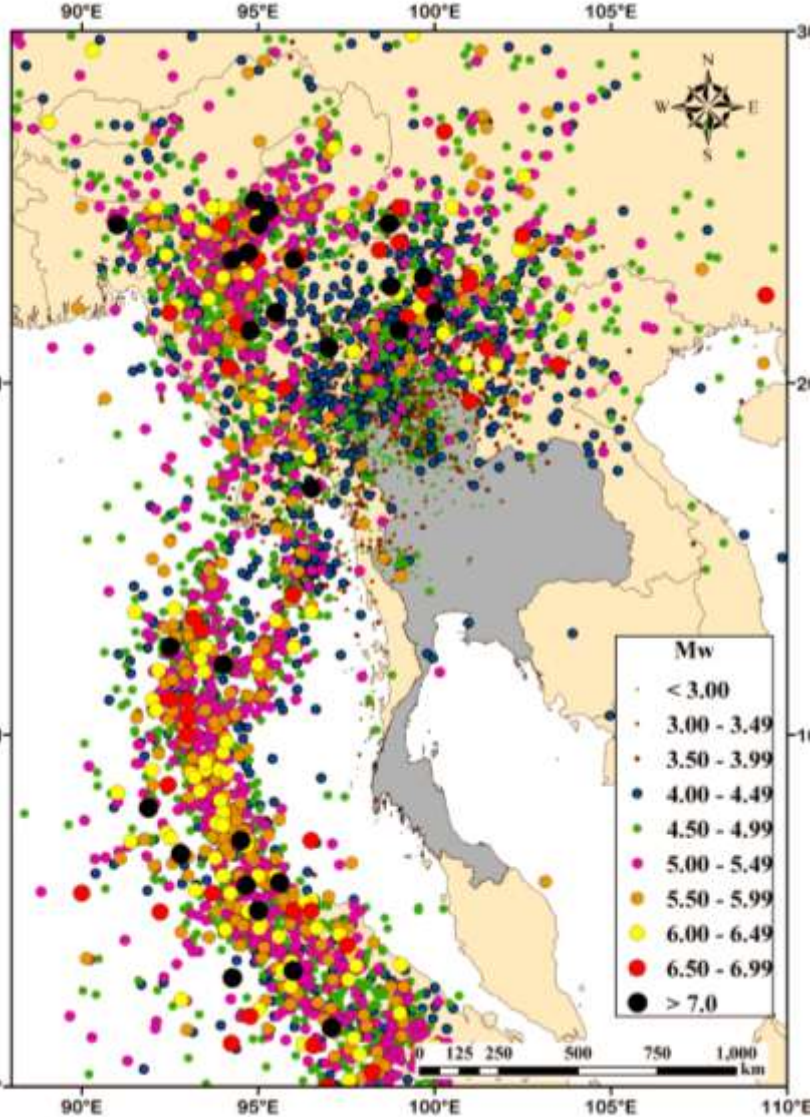
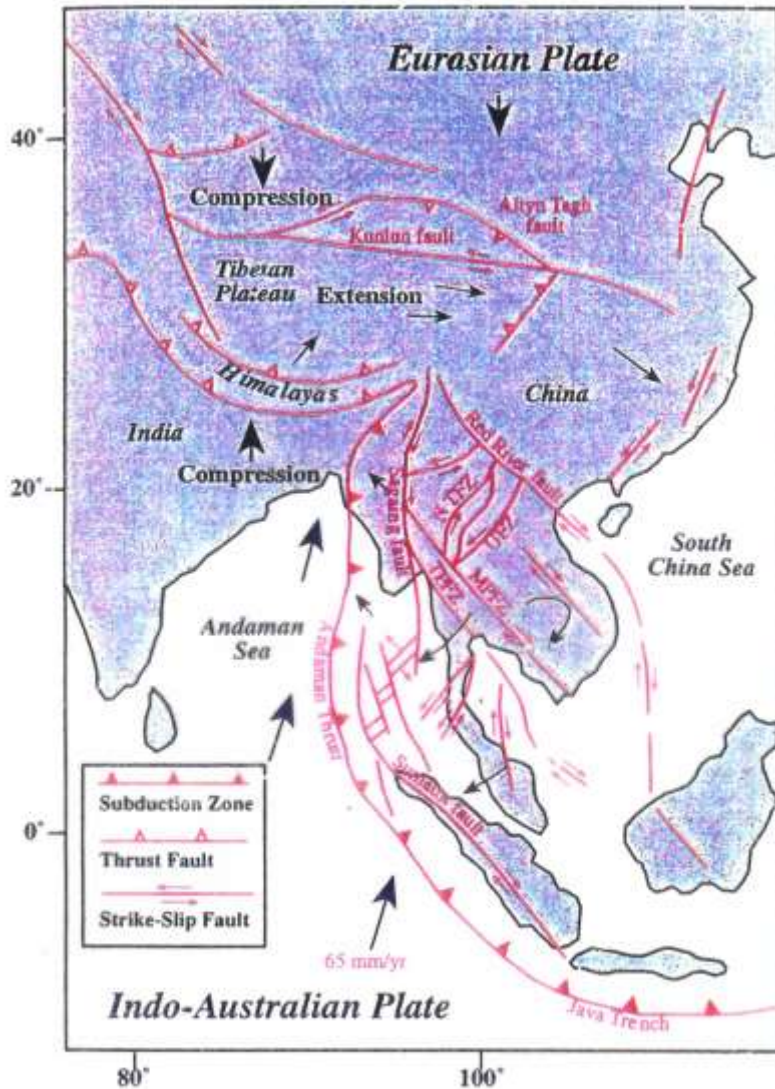
Zones of Extension within continents

Uncertain plate boundary



Tectonic Map of SouthEast Asia

Seismicity Map of SouthEast Asia (1912-2007)

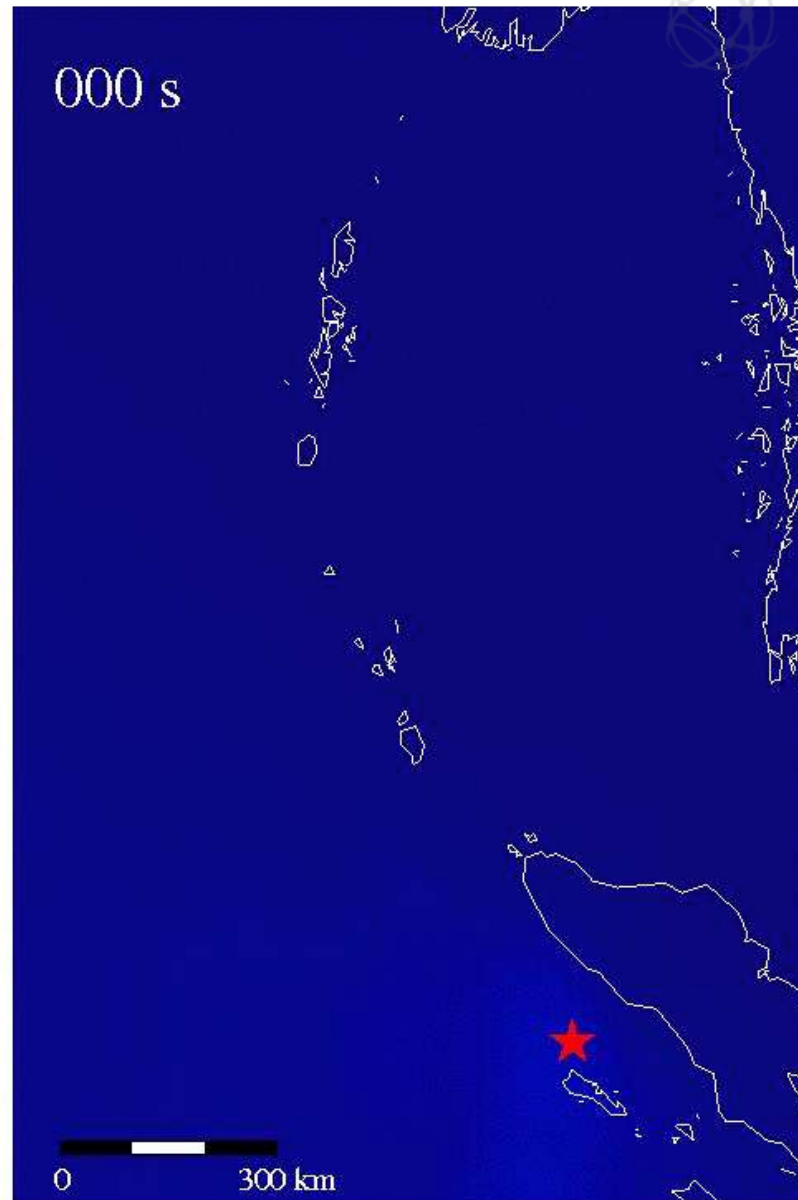


(after Polachan et al., 1991)

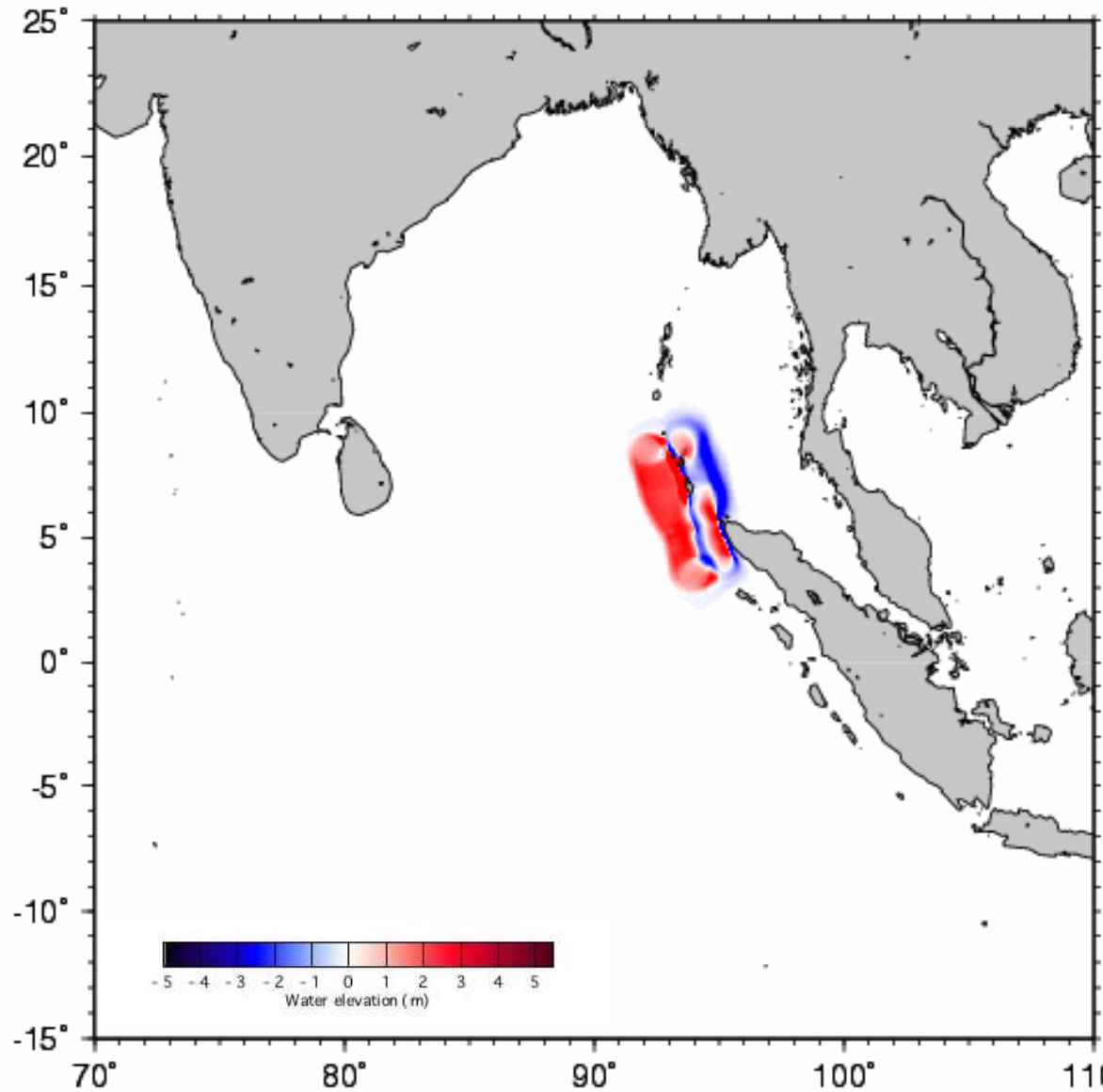
**The 26 Dec 2004
Megathrust EQ**

Magnitude: 9.3

***Rupture Length:
1200 km***



**Ishii et al., 2005
Nature**



Tsunami Flooding

Kamala Beach, Phuket



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Khao Lak, Phang-Nga

Maximum Water Level



One of the most devastating disasters for many countries surrounding Indian Ocean

Low-frequency but high-impact disaster caused by EQ

Improve public awareness of EQ risk





The Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)

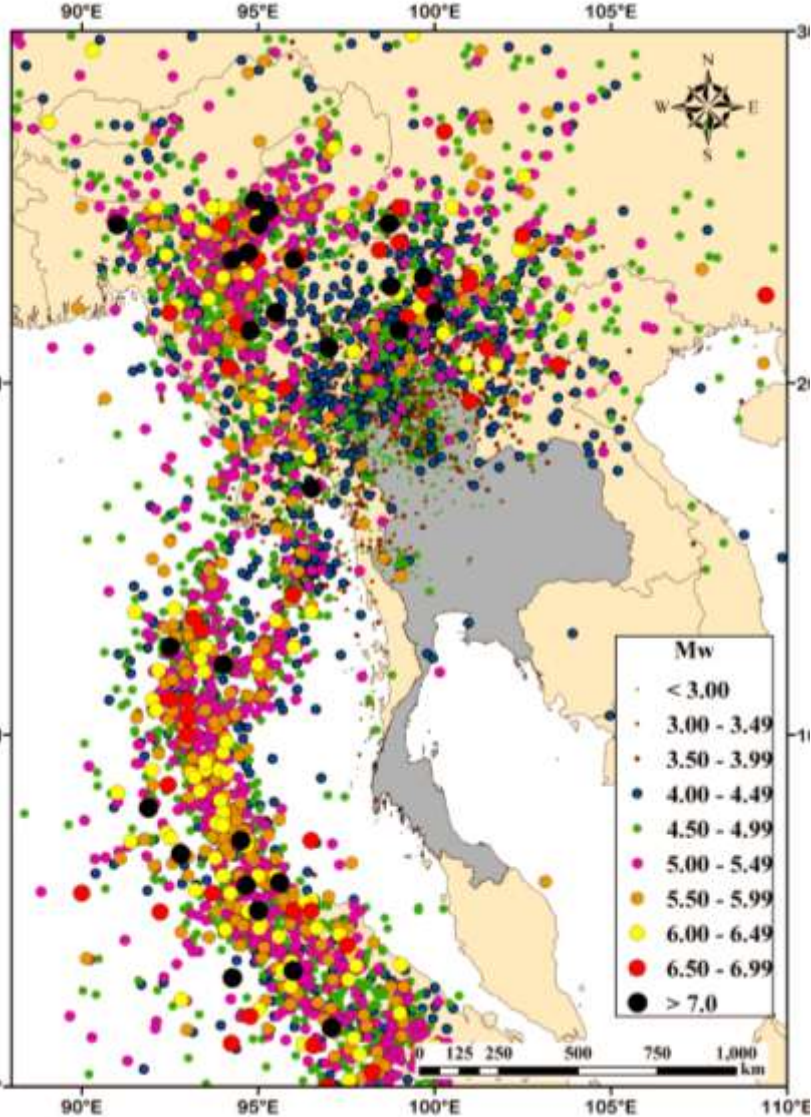
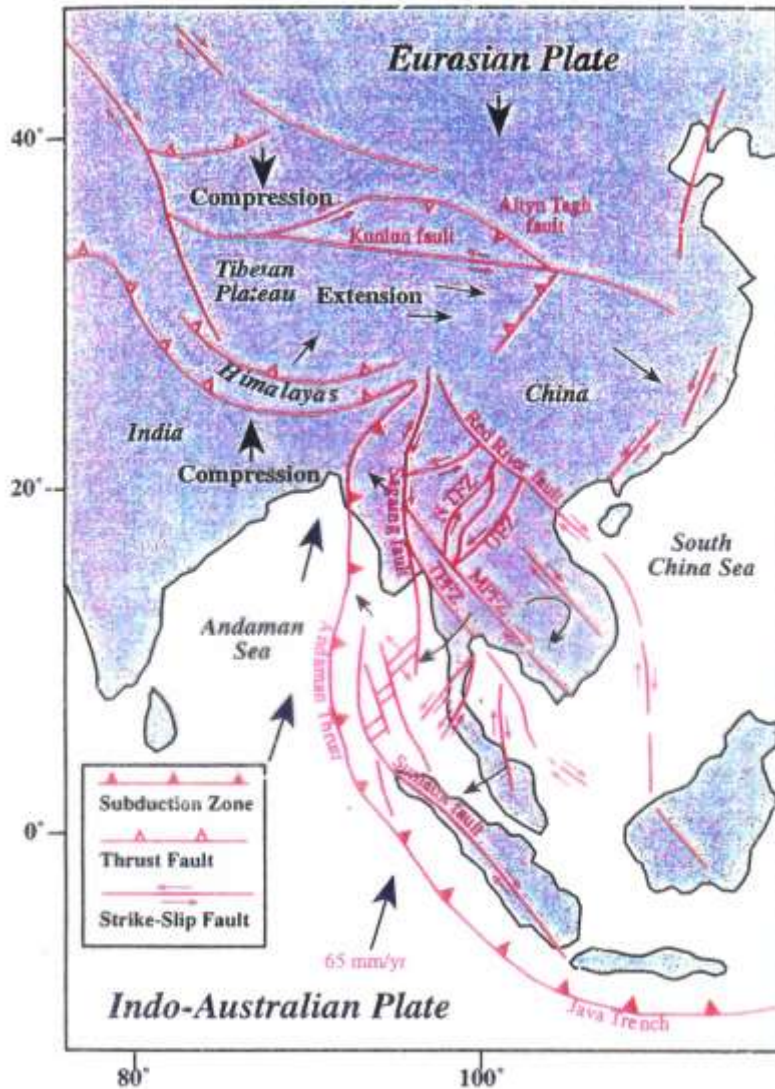
*Developed by ADPC,
Located in the AIT campus*





Tectonic Map of SouthEast Asia

Seismicity Map of SouthEast Asia (1912-2007)



(after Polachan et al., 1991)

An aerial photograph showing the aftermath of a major earthquake in Port au Prince, Haiti. The image captures a dense urban area where many buildings have been reduced to rubble. A prominent feature is a large, multi-story concrete building on the left side, which appears to be a school or government building, with significant structural damage. In the center, a blue banner with the word 'TELECOM' is visible amidst the debris. The surrounding area is filled with smaller, more densely packed structures, many of which are also in various states of destruction. The overall scene is one of widespread devastation and loss.

Haiti Earthquake (Jan 12, 2010)

M 7.0, focal depth 13 km

Downtown Port au Prince

Death Toll > 200,000

Yogyakarta Earthquake (2006)

Magnitude = 6.2

Death Toll = 5,000





Christchurch Earthquake

(February 22, 2011)

M 6.3, Death Toll > 200

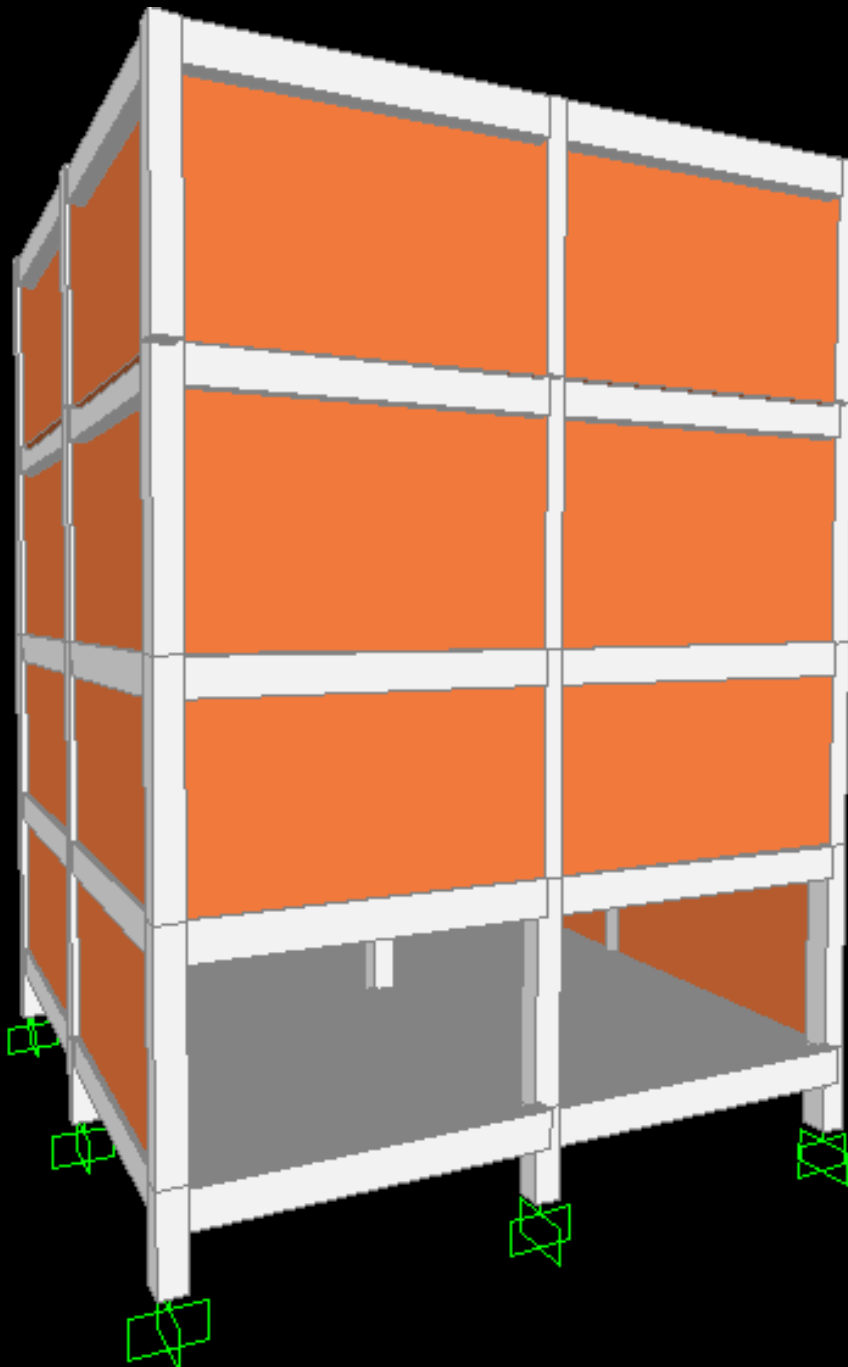


Basic Problem : The majority of existing buildings are vulnerable to earthquake ground shaking !



Typical Commercial Concrete Buildings



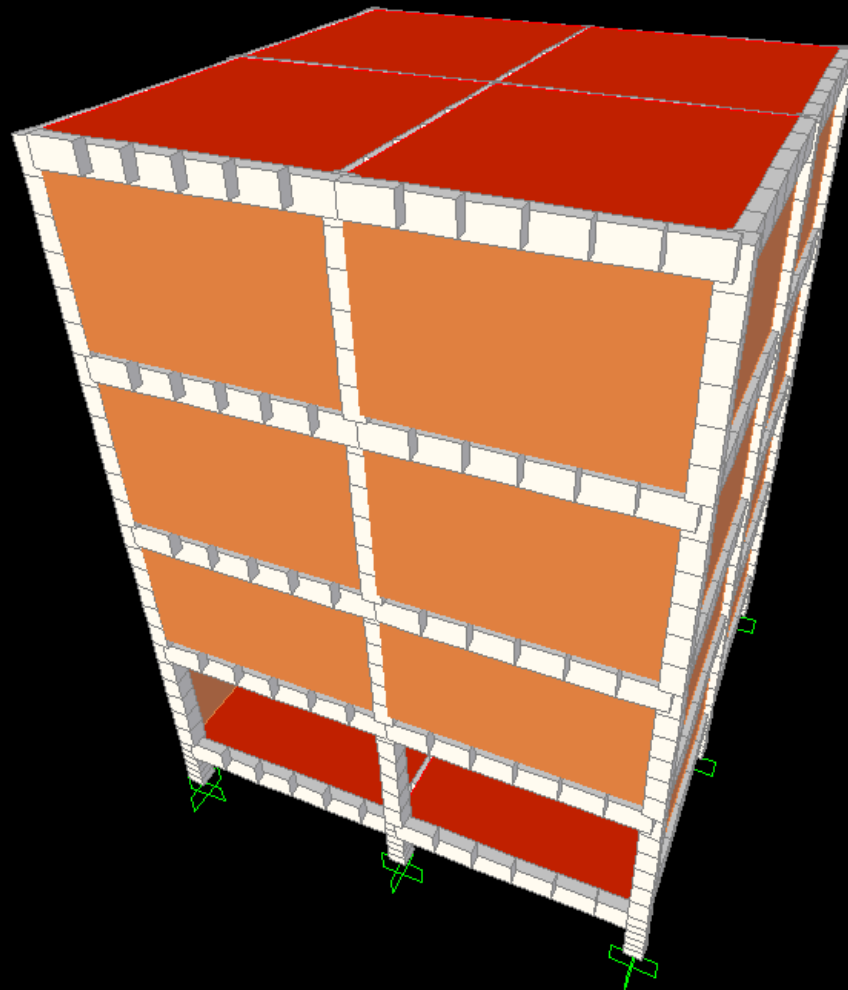


VULNERABILITY FACTORS

- **Non-seismic Detailing**
- **Strong Beam–Weak Column**
- **Soft/Weak First Story**
- **Torsional Irregularity**



Elastic Dynamic Response (Modal Analysis)



Lateral-Torsional Movement (period = 0.50 sec)

Soft-story Collapse of Commercial/Residential Buildings in the 1999 Chi-Chi Earthquake (Taiwan)



The 1985 Michoacan Earthquake ($M_s = 8.1$)

The earthquake caused considerable destruction and loss of life in Mexico City, about 350 km from the EQ epicenter. The number of deaths was more than 10,000.



Seismic Risk of Tall Buildings from Distant Large Earthquakes

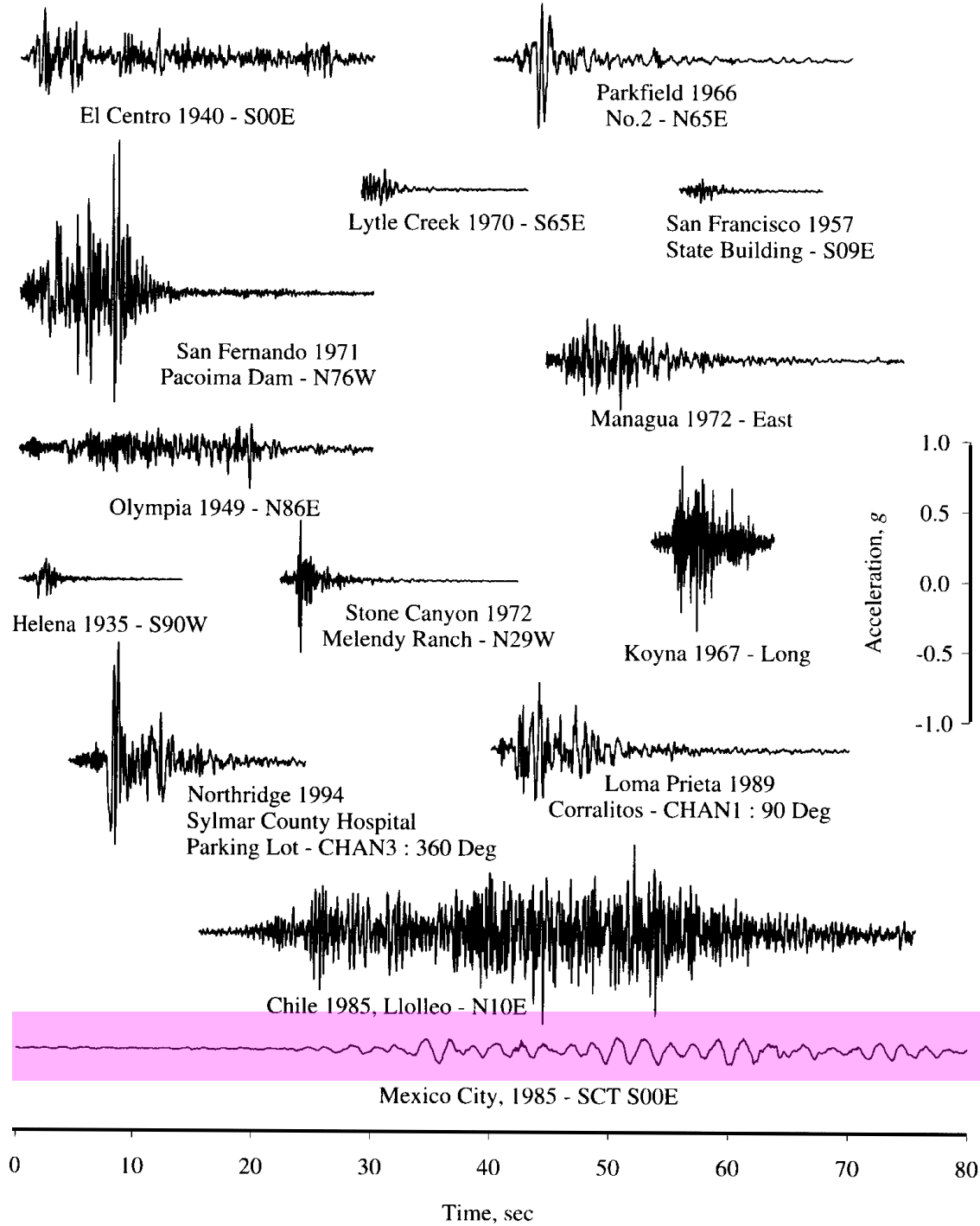
Earthquake Disaster in Mexico City (1985)

Much of the destruction was due to significant amplification of EQ ground motions by thick soft soil deposits.





Acceleration-Time Histories of EQ Ground Motions

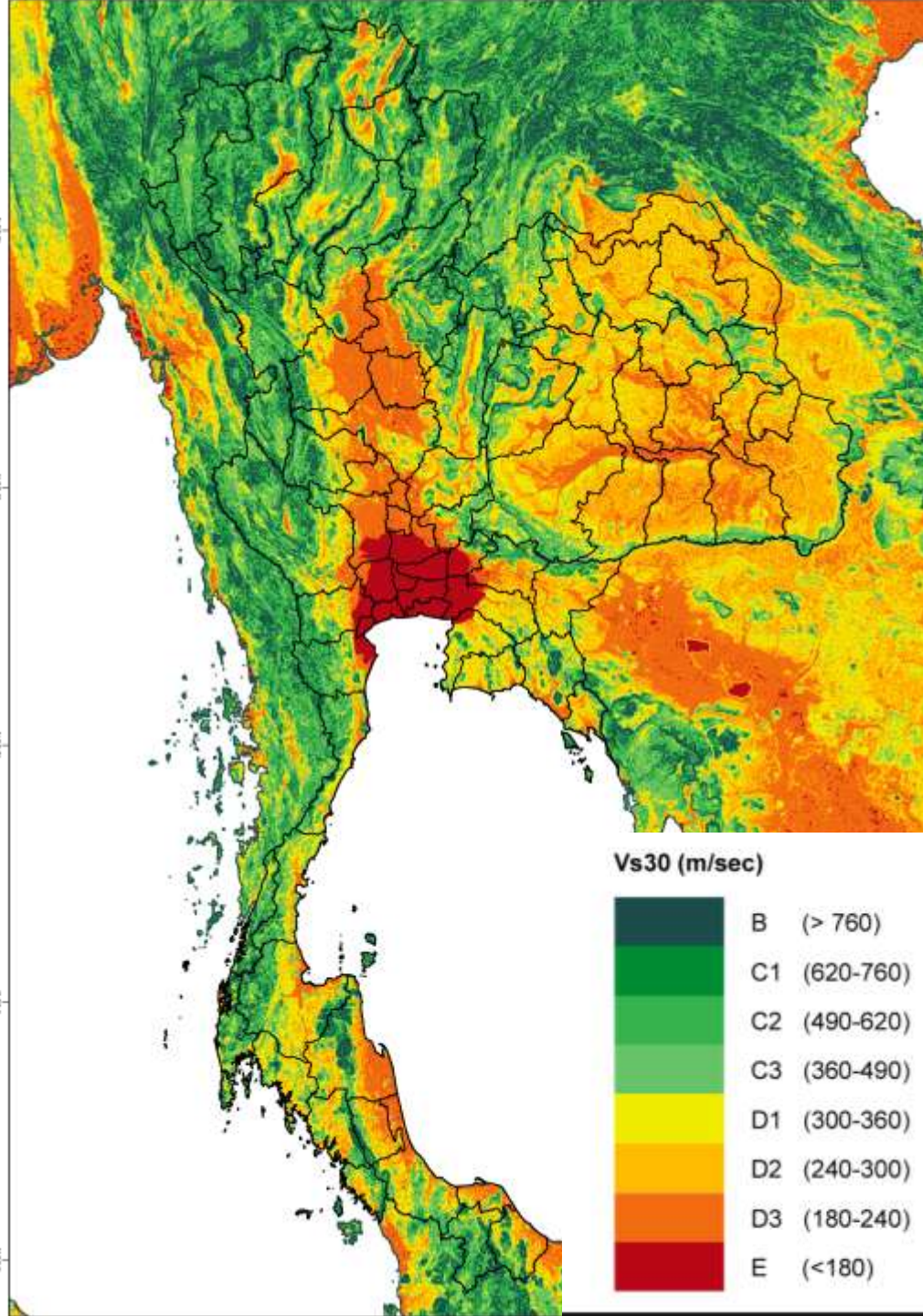


Shake Table Experiment





Map showing Soil (Site) Conditions in Thailand (derived from digital elevation data—SRTM30 and boreholes data)



Rock (No Amplification)

Very Stiff Soil

Stiff Soil (Moderate Amplification)

Moderately Soft Soil

Very Soft Soil (High Amplification)

SHAKEN

- Tremor spreads panic among Bangkok office workers
- 2,000 vocational students flee college in Phuket
- Epicentre of earthquake located off Sumatra island

■ The Nation

OFFICE WORKERS and people living in skyscrapers in Bangkok and several major suburbs either were a panic for more than an hour yesterday reacting after feeling the vibrations of an earthquake originating off the Indonesian island of Sumatra.

The higher the building, the stronger the effect of the quake. Residents of skyscrapers locked in their building's elevators. Those who reached the ground floor found crowds of people heading to get outside. Many of them rang fire bells and barely visible among the public service FM 100 radio station reacting immediately after the quake.

The panic subsided after the authorities announced the location of the tremors, which originated from Sumatra Island, 1,200 km from Bangkok and 300 km from Phuket, was felt yesterday. By the time the tremors reached Bangkok, we experienced it as a 2.2-magnitude," said Dr Prapantak Intanont, director-general of the Meteorological Department (MET).

Although Thai weeks initially reported that the quake measured 2.2 on the Richter scale, the MET's official figure is 2.7. International news agencies have said the quake measured 4.5-5.0 on the Richter scale.

"Don't panic. The quake is over. It was not enough to cause damage and was not centered in Bangkok," the MET chief said.

"In fact, by the time the quake reached Bangkok it was a low magnitude because it became the edge of the area of the low wall effect, which we find the effects of the quake by three to four times the Department of Mineral Resources (DMR) and the general Samsak Jitthasart said.

Natural Resources and Environment Minister Prapantak Intanont offered the following for coping with tremors: "Make balconies strong; furniture will not collapse; you, avoid standing in front of windows, doors and other exterior on your car until the vibrations are over."

"The public's main concern was over the shaking in skyscrapers, especially in Bangkok. There are some 700 buildings in any one of the centres tall. Experts want to grant height to you to safety their lives."

"Bangkok does not have an active fault system



LOCAL BELL: Bangkok tremble

After the crash of 1997, nothing scares us, says capital's 'Wall St'

■ Mantira Narkevivichien THE NATION

A MILD EARTHQUAKE struck the heart of Bangkok yesterday, but downtown workers said half-jokingly it wasn't as bad as when their businesses were hit by the 1997 economic debacle.

Staffers of KGI Securities on the 40th floor of the United Building on Silom Road, the capital's "Wall Street," took a break from their work to chat about their fears of economic downturns, according to an employee, who requested anonymity.

"The employee told *The Nation* that everyone left the office for an hour yesterday, but that the staff



Seismic Risk in Bangkok due to Distant Large Earthquakes



...a quake originating from the Indian Ocean ridge... from Sumatra Island, 1,200 km from Bangkok and 300 km from Phuket, was felt yesterday. By the time the tremors reached Bangkok, we experienced it as a 2.2-magnitude," said Dr Prapantak Intanont, director-general of the Meteorological Department (MET).

เดลินิวส์

ผวาตึกระฟ้าถล่ม แผ่นดินไหว หนีตายอลหม่าน

โบหยก-ภานุครอง โกลหลไปหัว ได้สะเทือนหนัก-เม็กซิโกตายอ้อ!

สภามันมือบ่พยามลด กตตัน'ตตัน'าคัดไฟ

saw the veteran mind and the partition in his work area shaking. He said he and his colleagues were

Quake leaves Phuket

■ *The Nation, Phuket Gazette*

TREMORS from an earthquake centred off the Indonesian island of Sumatra yesterday morning frightened people in tall buildings in Bangkok and triggered a stampede from the Phuket Vocational College at Saphan Hin, Phuket Town.

About 2,000 vocational students in Phuket's Muang District were told to make a hurried exit from the college buildings, which were rocked by an earthquake with a magnitude of 2.7 on the Richter scale

working on the same floor. When vibrations were felt, said that at first she thought there was something.

10am. "I felt nausea from the shaking but I did not realise that it was due to an earthquake," she said.

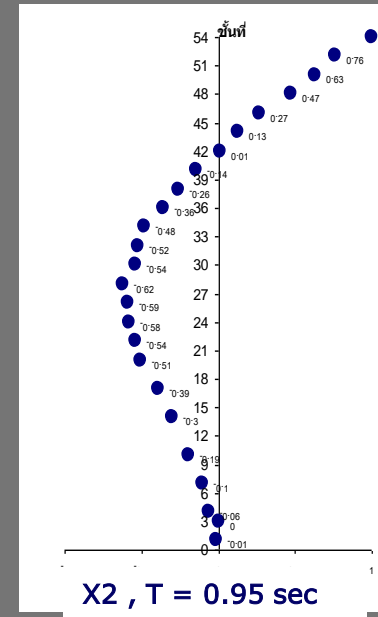
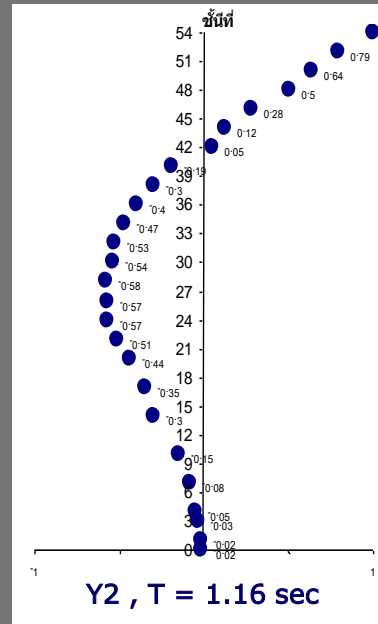
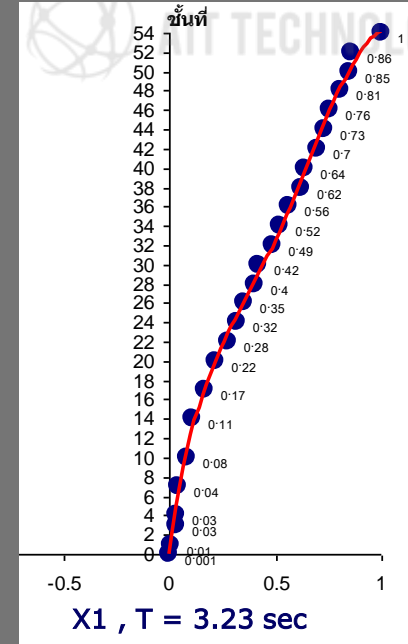
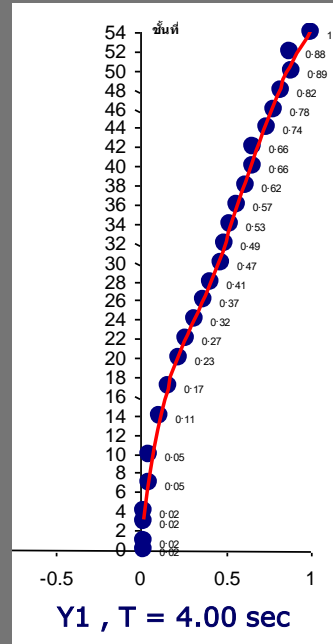
Tuanjai Panmakit, a college librarian, said at first when she saw a chair moving she thought it was because it was on wheels, until she saw bookshelves shaking too.

When students in the library told her they thought it was an earthquake, they all ran down.

■ "I felt from the I did not it was an ear ORACHIT D...

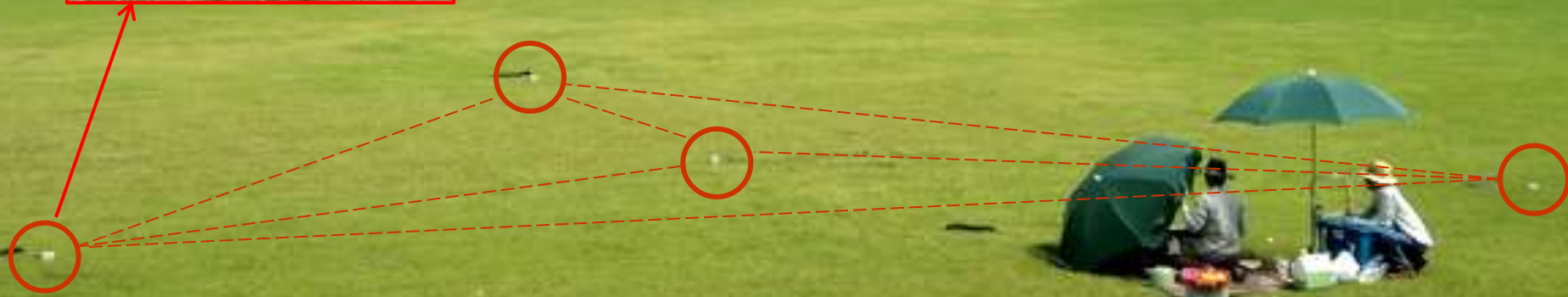
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Measurement of natural periods and vibration mode shapes of tall buildings in BKK

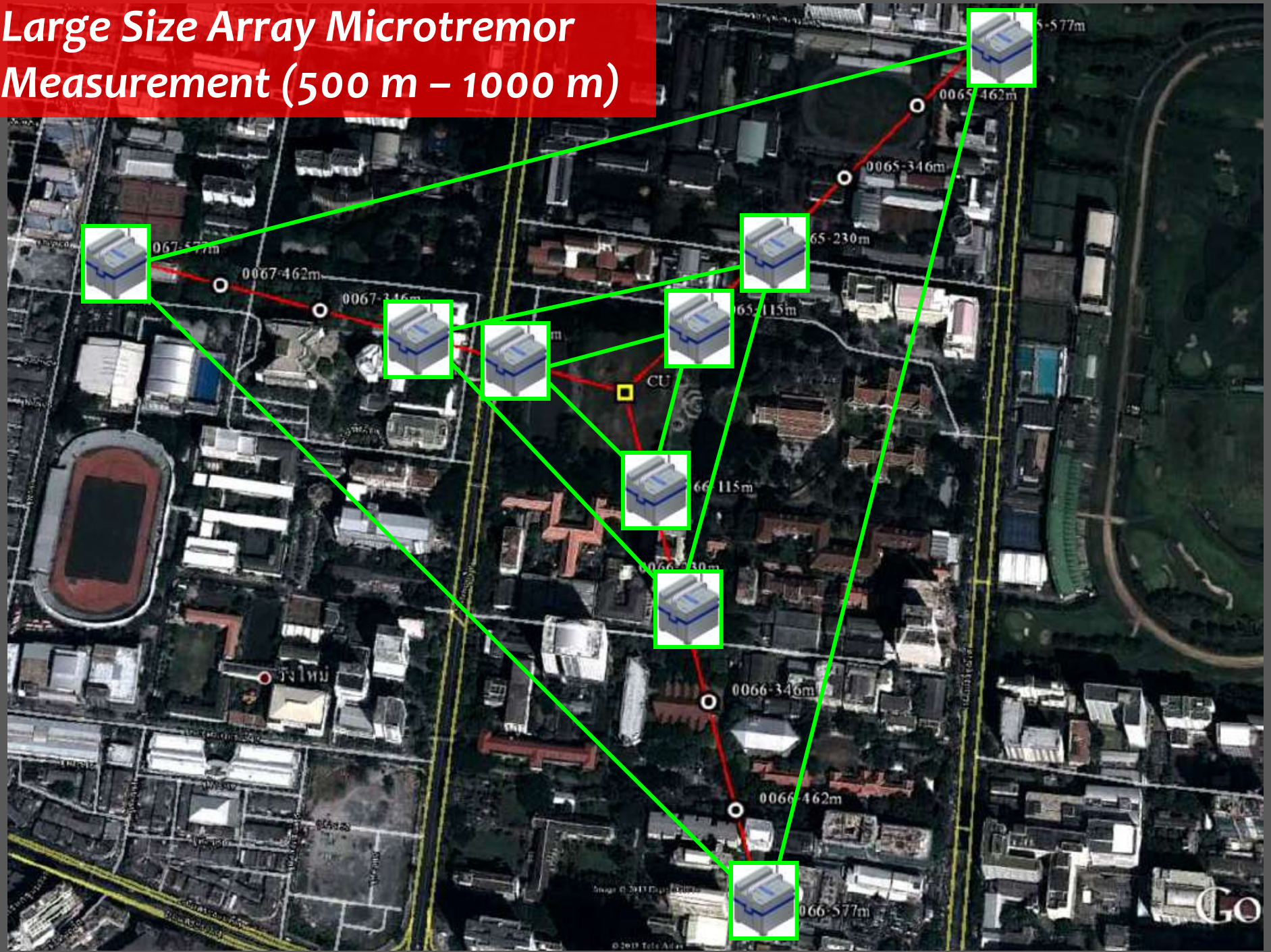




Identification of Dynamic Properties of Bangkok Soil Basin by Array Microtremor Measurement



Large Size Array Microtremor Measurement (500 m – 1000 m)

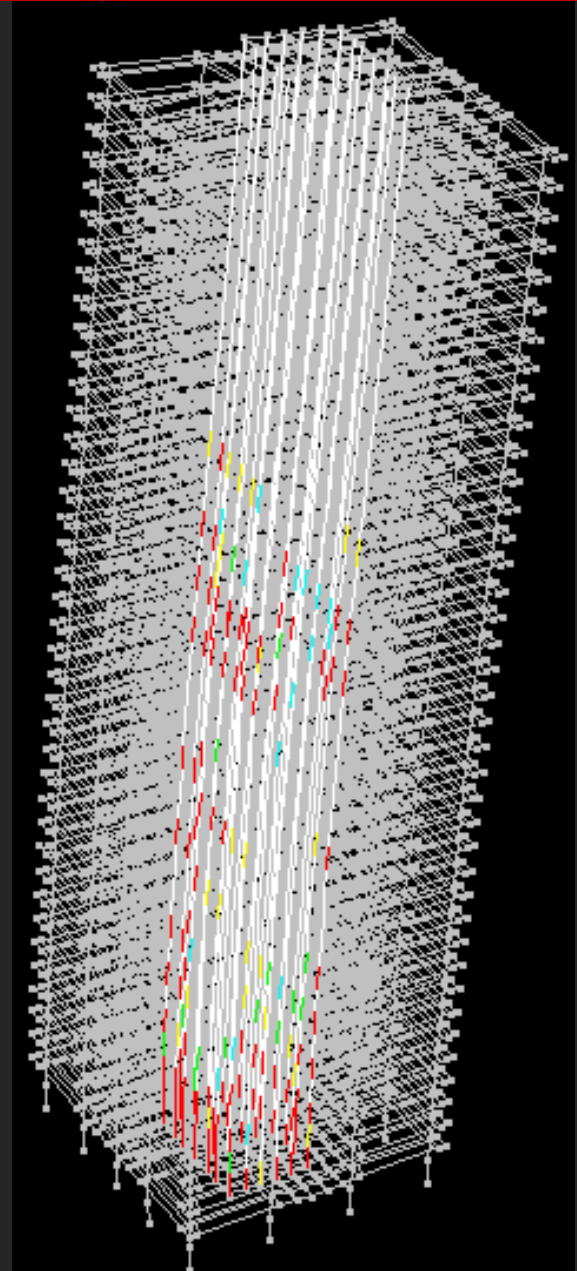
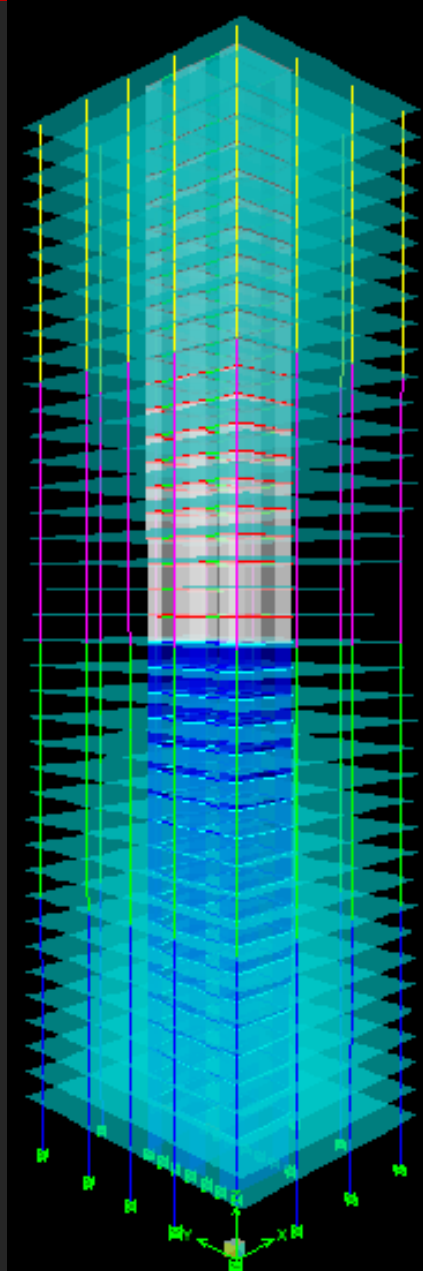


Nonlinear Finite Element Model of Tall Buildings in BKK



Construction drawings of more than 200 tall buildings are being collected.

Their performance under extreme seismic events are being evaluated.



Damages and Losses in BKK from Possible Earthquake Scenarios



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Satellite Image of a Typhoon

Typhoon = Hurricane = Cyclone =
Tropical cyclone with surface wind speeds > 120 km/hr

Max. Typhoon winds may reach 320 km/hr.

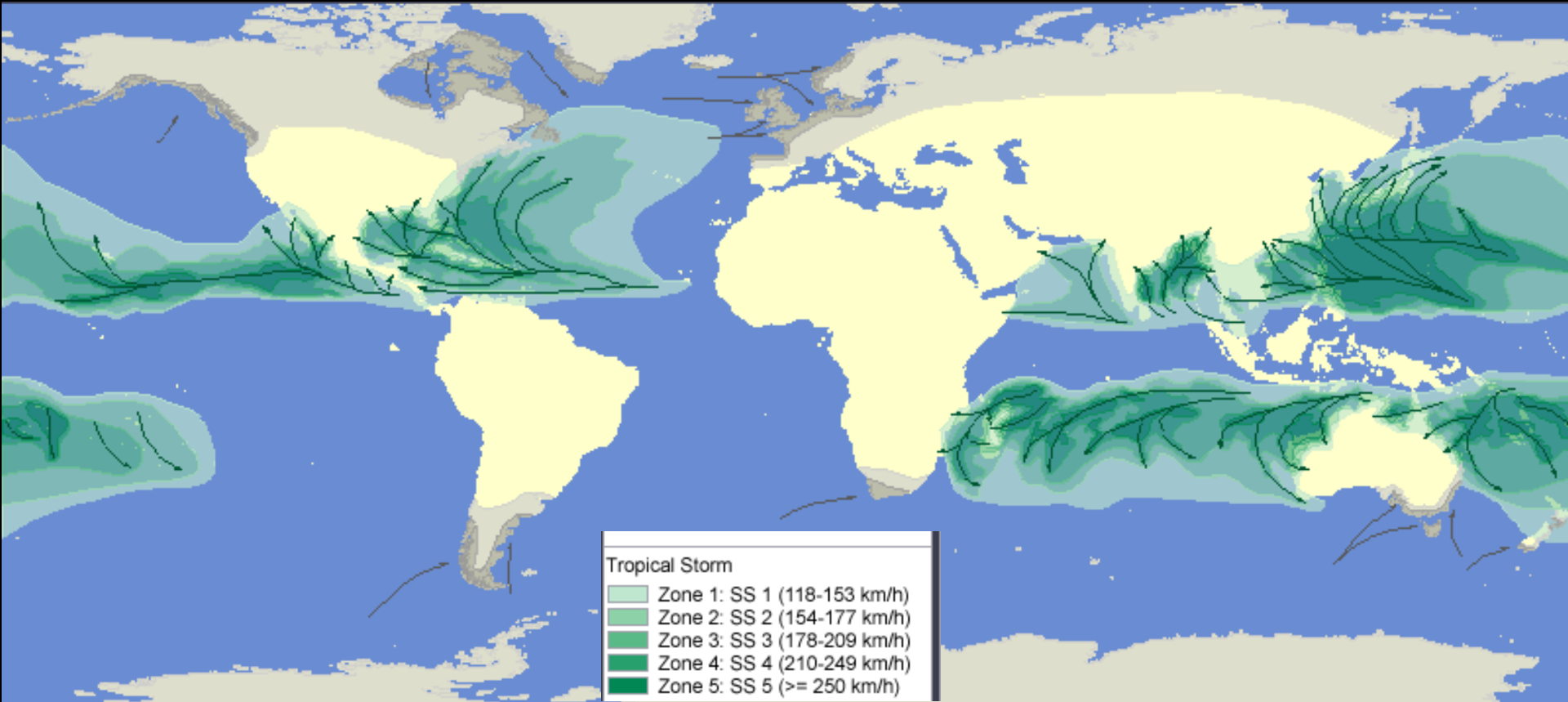
Hundreds of kilometers in Diameter

World Map of Tropical Storm Hazard

(Tropical Cyclones, Hurricanes, Typhoons)



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Thunderstorm



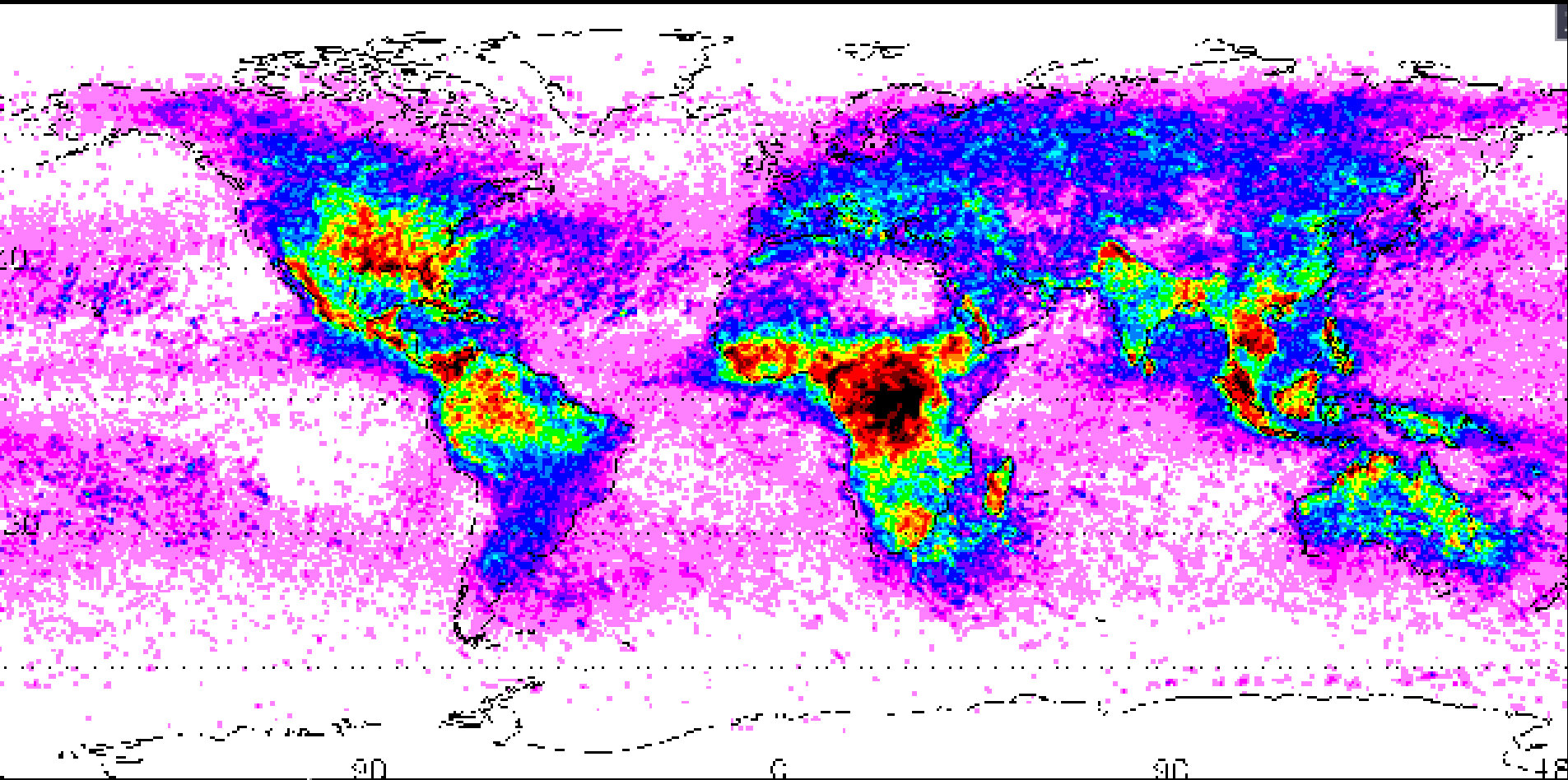
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- 
- A photograph of a thunderstorm over a lake. The sky is dark and cloudy, with a bright lightning bolt striking down from the clouds. The lake is in the foreground, and there are trees and mountains in the background.
- *Small-scale wind: Kilometers in diameter*
 - *Produce lightning flashes*

World Map of Lightning Hazard



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Orbits	11290
Areas	519244
Flashes	2704444
Groups	12863929
Events	26006503



April 12, 1995 — December 31, 1997



Large Billboard Structures



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Collapse of a large billboard (50 m high) in Bangkok during a severe thunderstorm in June 2002



Several large billboards in Bangkok were completely destroyed by severe thunderstorms on 28th June 2007





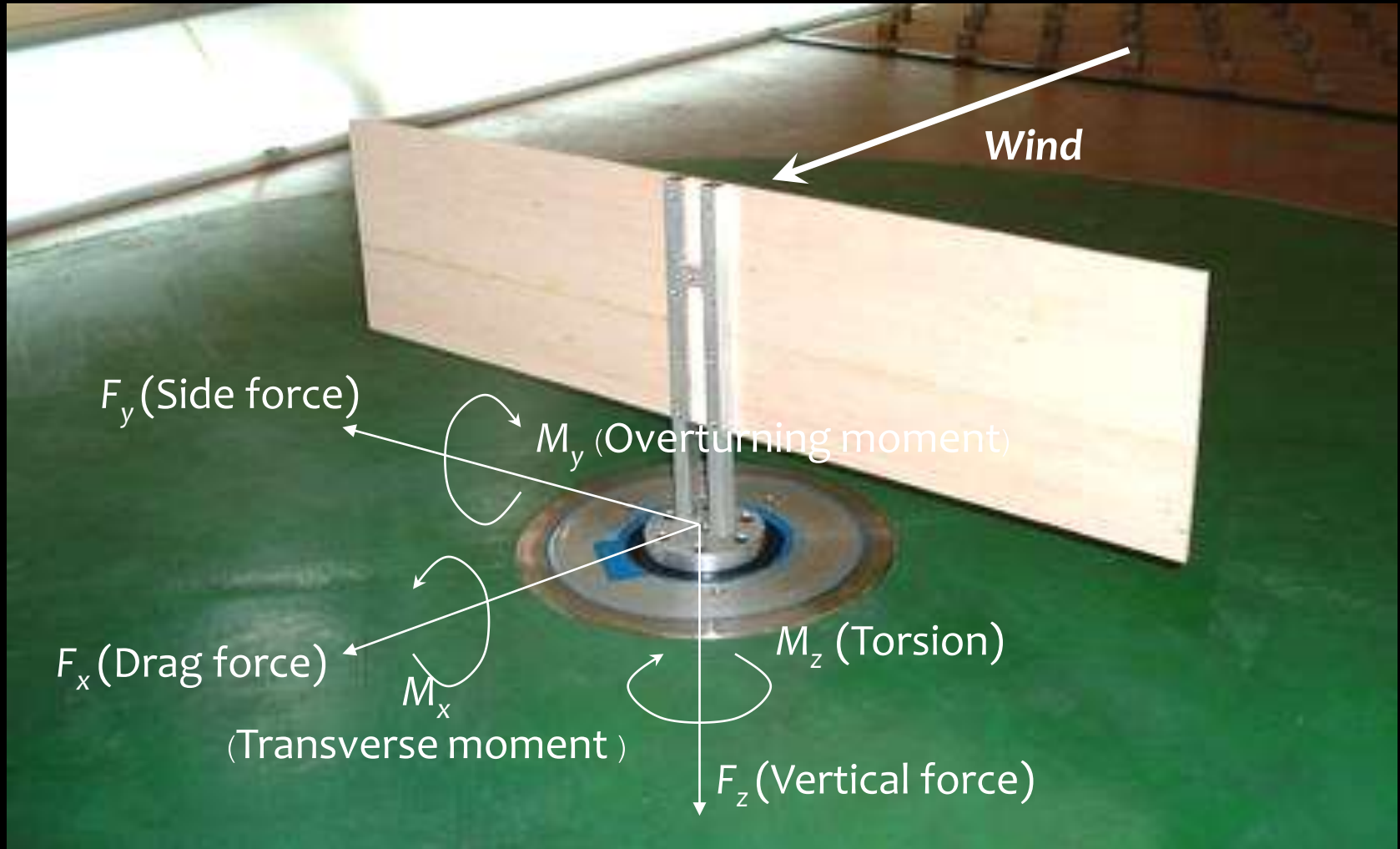
TU-AIT Boundary Layer Wind Tunnel Laboratory



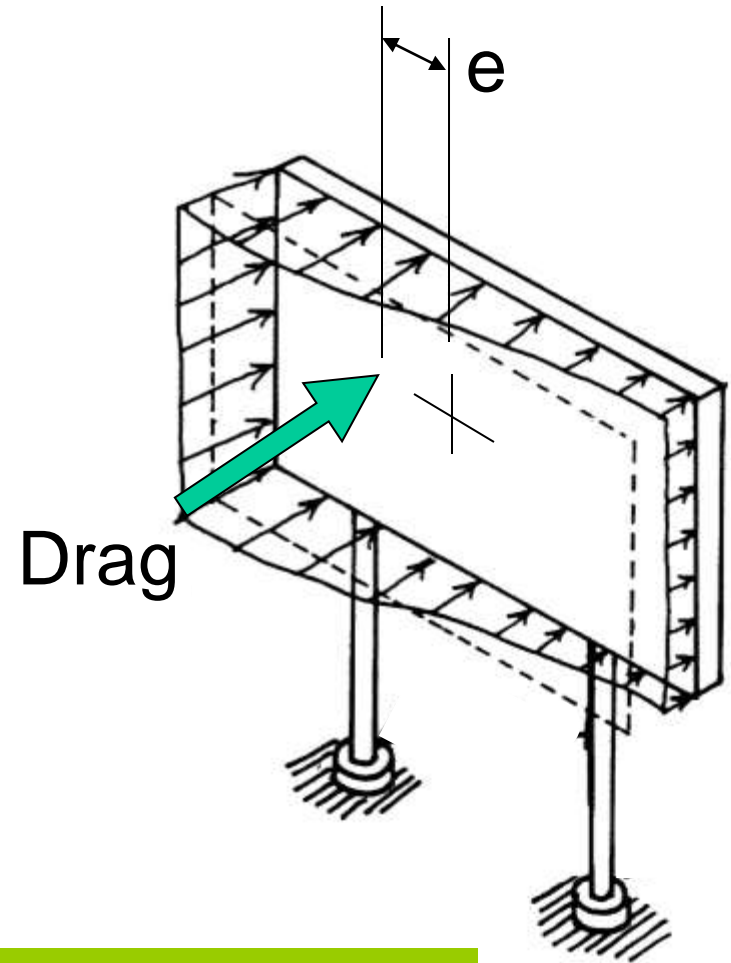
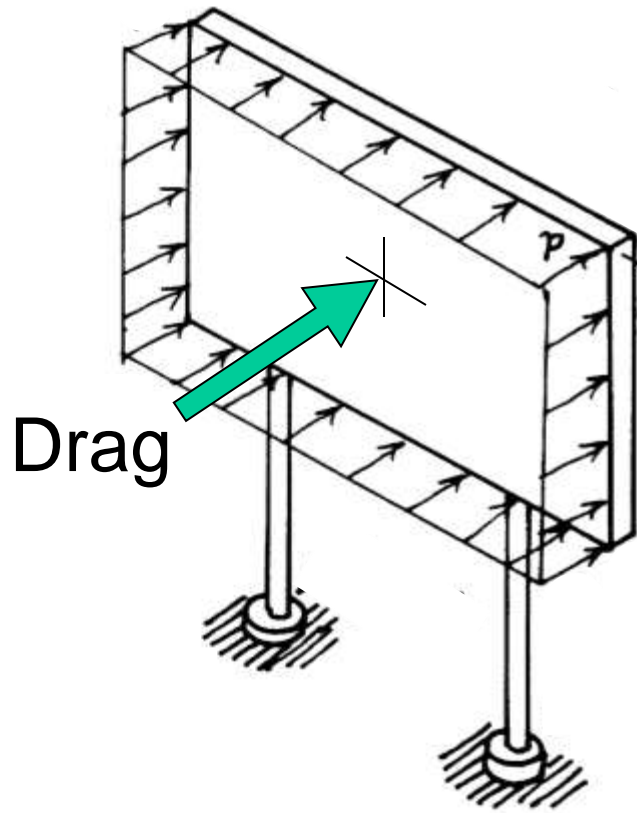


***A Scale Billboard Model
In Wind Tunnel***

Wind tunnel test on a scale billboard model To determine wind-induced forces



High Frequency Force Balance Technique



Drag x e = Torsion





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A 40-m Tall Buddha Statue in Kanchanaburi Province





Key Issues for Wind Tunnel Model Tests

- *Wind-induced vibration in top floors causing motion sickness*
- *Maximum wind pressure for cladding design*
- *Resonant amplification of structural response*
- *Effect of nearby buildings on wind loads*

Wind Tunnel Model Test of The 70-story Gramercy Residence Building with the presence of all surrounding buildings (Manila, Philippines)



The 70-story Gramercy Residence Building

Simultaneous Dynamic Pressure Measurement

CAARC Building Model
(180 m x 45 m x 30 m)





Dynamic Wind Pressure on CARRC Building

Thank You