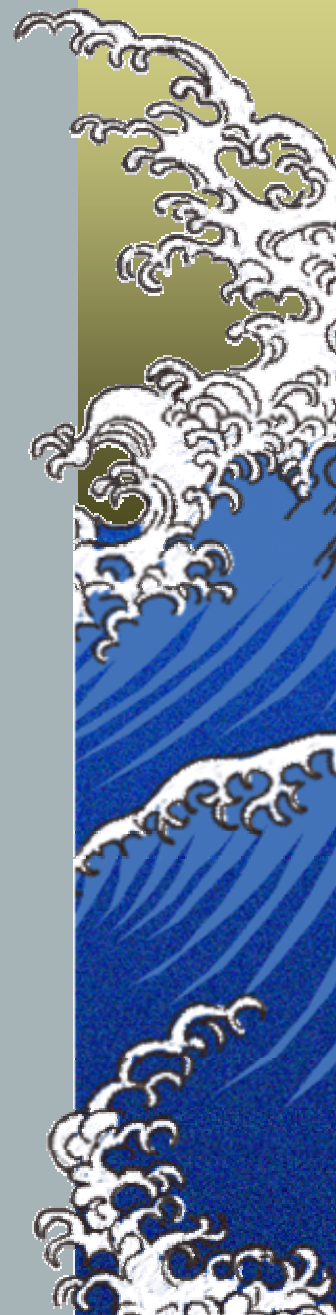
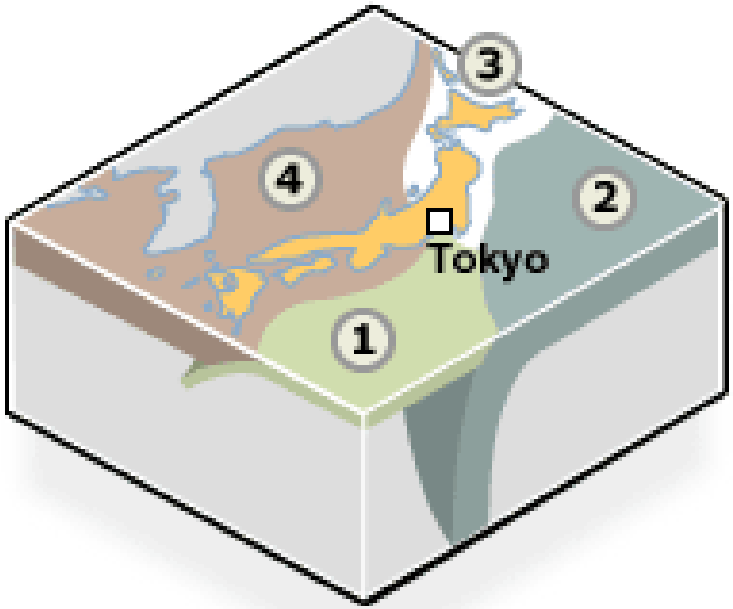
Civil Engineering Issues: Japan

Elizabeth Ervin

UM Office of the Provost



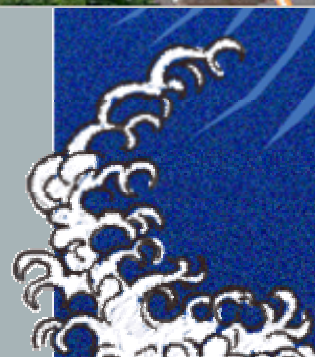
SHAKY FOUNDATIONS



KEY:

1. The Philippine Sea Plate
2. The Pacific Plate
3. The North American Plate
4. The Eurasian Plate

Dangers…



Last 2 Major Tokyo Earthquakes

1855 (Ansei-Edo)

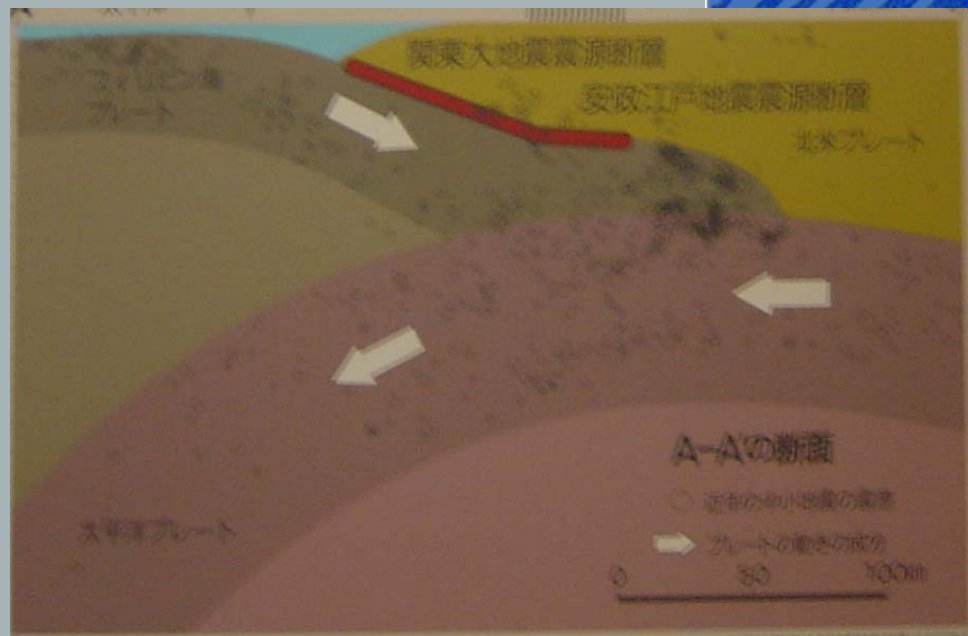
Epicenter below the city

1923 (Great Kanto)

Epicenter in Sagami Bay

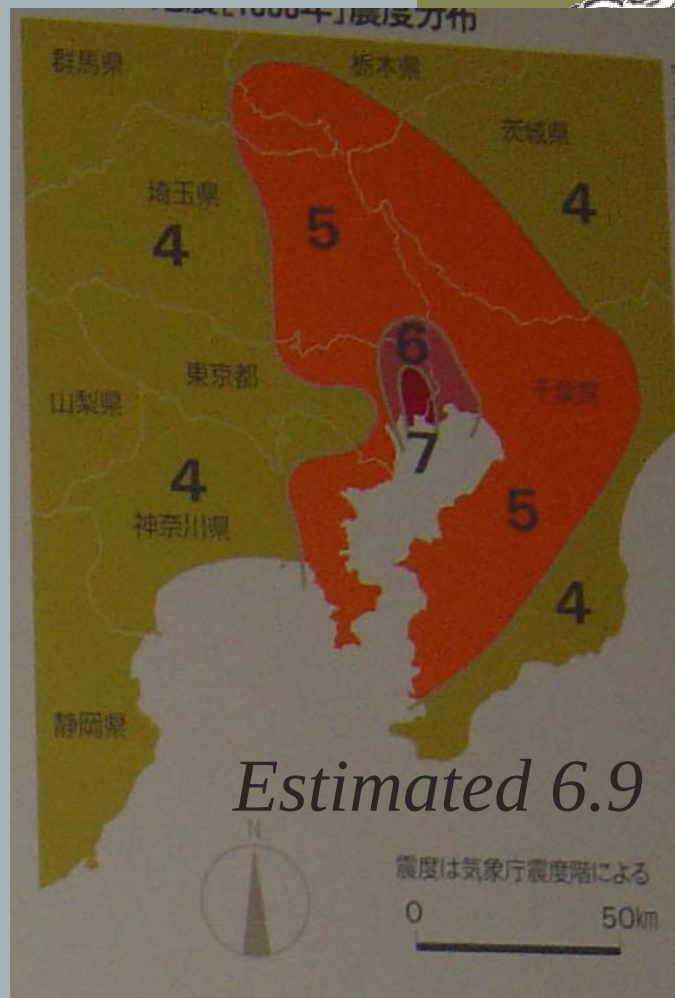
+16th century record: major Tokyo quake every 80 years

Subduction Zone



The 1855 Earthquake: Oct. 2, 1855

- Versus 1923: 1855 more violent
  - Edo was not yet modern, so easier recovery
  - 10% of buildings collapsed, 2.5 times more
  - 1400 storehouses collapsed, 36 times more
- Total of about 10,000 casualties
  - 90% from collapsing structures
- 50 different fires, 2.2 km^2 burned, 4700 people died, 1074 of which burned in Yoshiwara
- 16000 ruined buildings
- Whole country aided in rebuilding, not enough though. Even relief huts from merchants.
- Actually money in Tokyo!



Estimated 6.9

September 1, 1923 11:58am

- Greatest damage and loss of life in history: 71,000 people killed or missing in the city alone;
- Lunchtime! Fires broke out all over.
  - Fanned by strong winds, nearby typhoon
  - Broken water mains were no help
  - Downtown had densely packed wood buildings
- Officially, 7.3 on Richter Scale
- Up to 24ft upheaval, 800-1,000 die from landslides
- 10m-11m tsunami
- More energy expended than in WWII

1923 Quake Stats

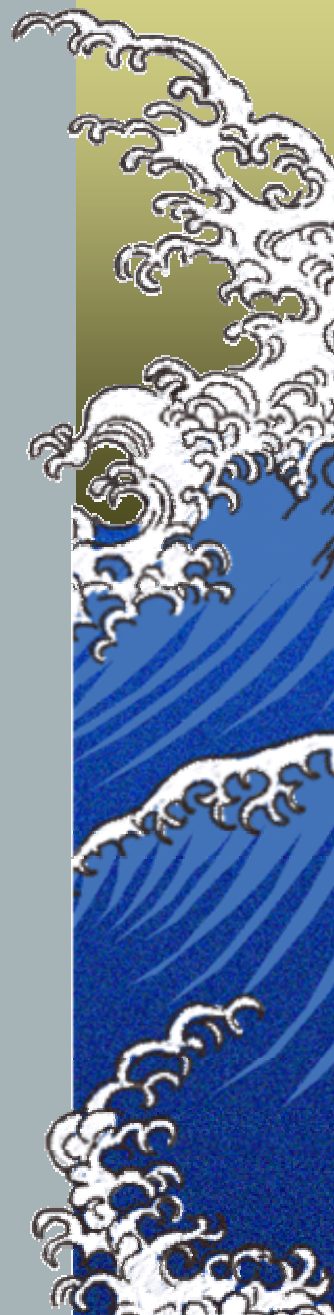
- 52,000 died from the 100+ fires before extinguished on Sept. 3
- Mass casualties at all public locations
  - 44,000 (or 33,000 or 38,000 or 40,000) people burnt in one clothing depot

- Aftershocks: 57; >300/day for 4 days
- Dead or missing: 100,000; 130,000; 140,000; 142,000; 142,807 (officially)
- Injured: 52,000; 103,000
- Surviving Tokyo population: 11,758,00
- Homeless numbers: 3,248,205 (officially); 1.9M; 1.5M
- 60%, 2/3, 71% of Tokyo destroyed

1923 Quake

Infrastructure

- 360 bridges of 675 impassible
- People could not escape the fires and jumped in the river, drowned
- One wood building remains in Ueno
- Brick and stone buildings crumbled but reinforced concrete buildings stood – little damage to the eye, so became most common building type
- Argued over the cost of rebuilding so government only did a few wide streets downtown
- Remainder of rebuilding fell upon the poor and the merchants

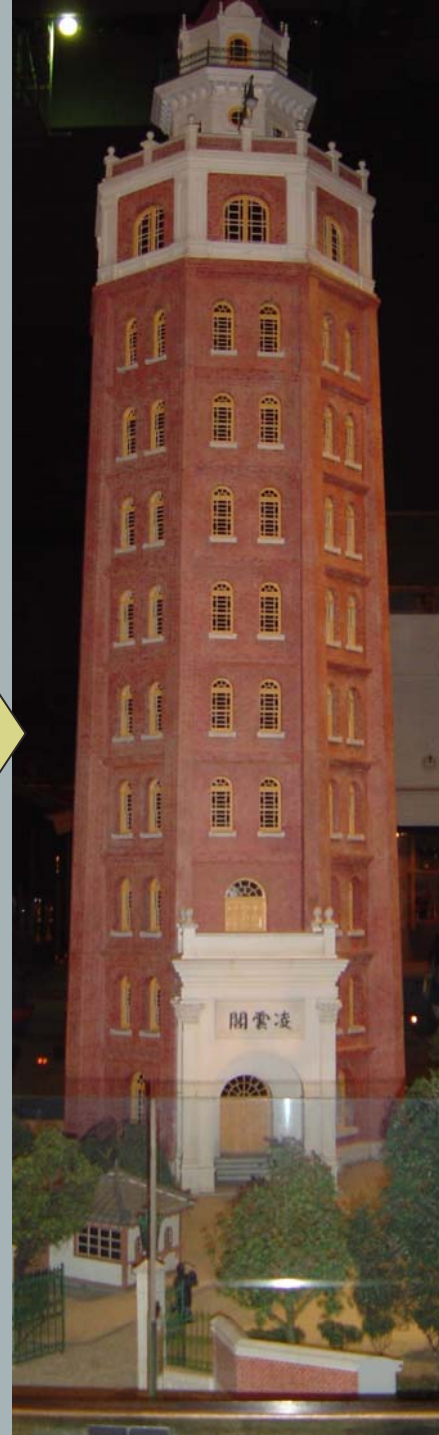


The Ryounkaku tower a.k.a. the “Twelve Stories”

- 60m tall, completed in 1890
- Popular Symbol of Asakusa
- Floors: 1-10 = brick; 11-12 = wood
- 1st elevator in Japan (to Floor 8) but closed for safety

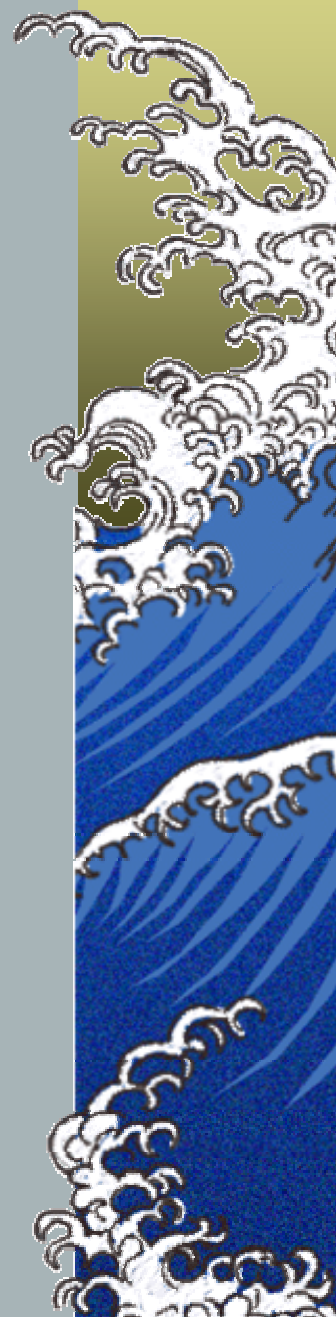
After

Before



1923 Quake Aftermath

- Stop of all communication → social chaos resulted.
- Martial law was proclaimed on Sept. 2 (or Sept. 8)
- Order via military police and civilian vigilantes
- Several incidents where countless people were massacred/assassinated.
  - Communists, socialists, Koreans targeted



<u>Wild rumors and false reports</u>

Another great quake coming, islands sunk into sea, monster tsunami, socialists started riots, Korean burning/bombing/robbing and poisoning water wells

• Sept. 7 – new law banning spreading rumors and hearsay; order gradually restored

EQ Damage 1923

1,000+ year old gingko tree remains →

- *Kamakura: Hachiman Shrine*

700-year-old shrine destroyed

Rebuilt

More EQ Damage 1923

- *Kandabashi Bridge*

Damage: Before and After

Effects on Tokyo

- *Before: Wood single family dwellings*

- *After:* 1,470,000 move

RC multi-family dwellings and disorderly city sprawl

Rainbow Bridge (1993)

Cable suspension crossing
northern Tokyo Bay
570m span, 918m long
Tower 127m high
2 levels, 3 three train lines
Seasonal walkways
Solar lamps

Bridge Views Cont.

Bridge Views Cont.

Akihabara Bridge

Kachidoki Bridge
Drawbridge but not drawn since 1970

Onniboyashi Bridge

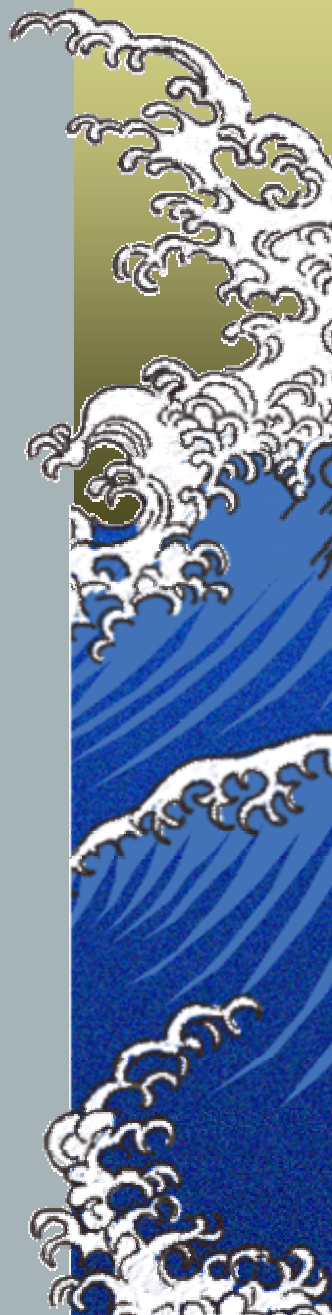
Nihonbashi Bridge

- Original wood built in 1603.
- Edo-Tokyo Museum replica→
- Historical center of Tokyo
- Granite arch in 1911.
- Metropolitan Expressway overshadows it, want to move the road!
- Washed every summer by 1,200 volunteers

Seismic Bridge Design

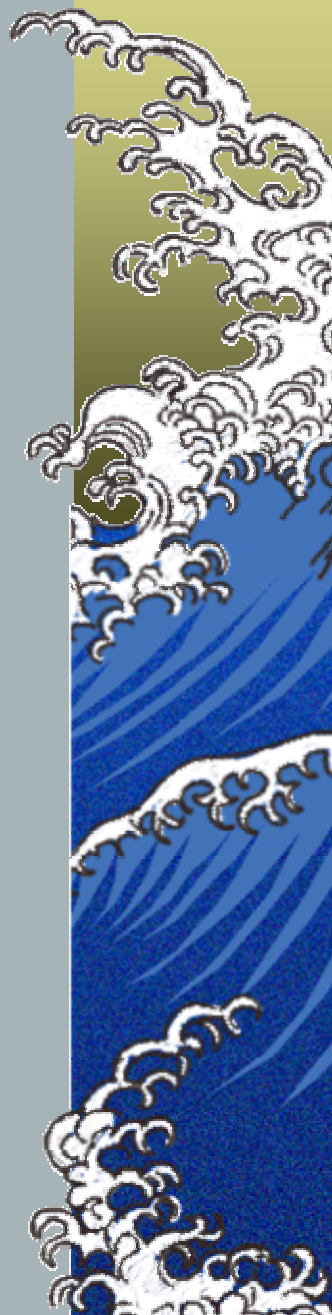
Structure Protection

- *Seismic Isolation*
  - *Elastomeric Bearings*
  - *Lead Rubber Bearings*
  - *Sliding Friction Pendulum*
- *Passive Energy Dissipation: Dampers*
  - *Metallic, Friction, Visco-elastic, Viscous, Tuned Mass, Tuned Liquid*
- *Semi-Active/Active Energy Dissipation*
  - *Active Bracing Systems*
  - *Active Mass Dampers*
  - *Variable Damping/Stiffness Systems*
  - *Smart Materials*



Japanese Seismically Isolated Bridges

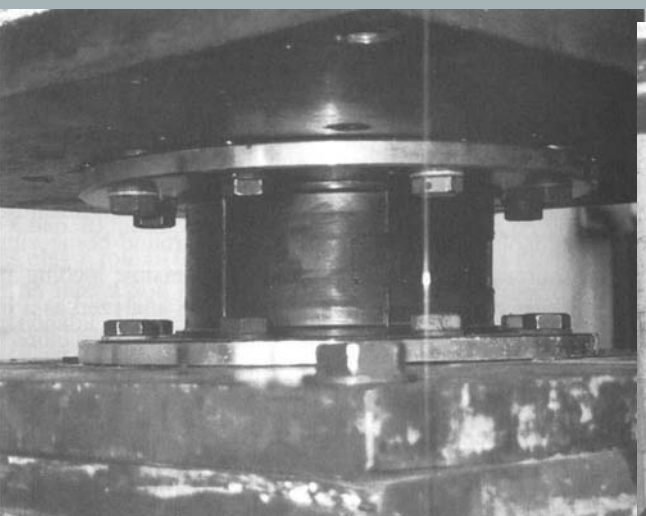
- *Lead-rubber bearing*
- *High damping rubber bearing*

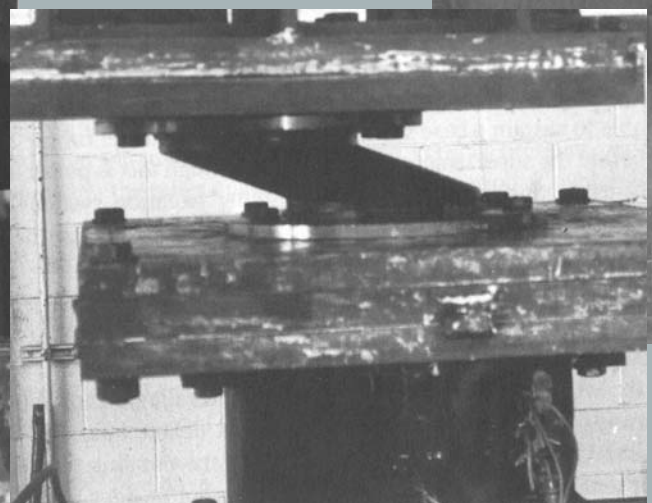


Rubber Bearings

- *Under Shear (Kelly)*
- *Under Tension*

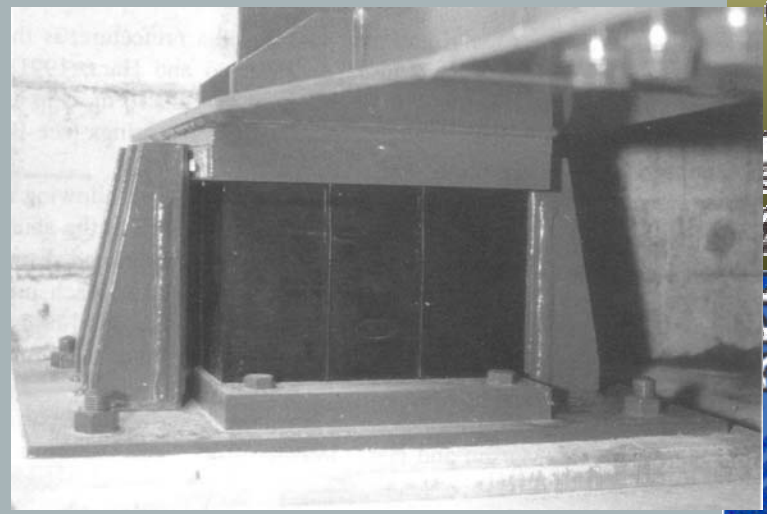
  (Skinner et al.)

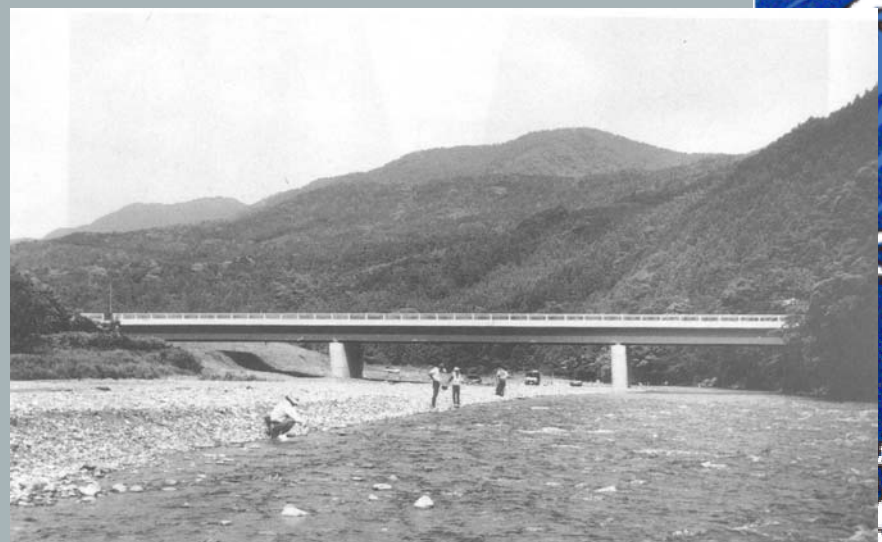




Miyagawa Bridge
Shizuoka, Japan

- *1991: First seismic-isolated bridge in Japan*
- *Lead-rubber bearing as transverse restraints*
- *104 m length, 3 span continuous girder*

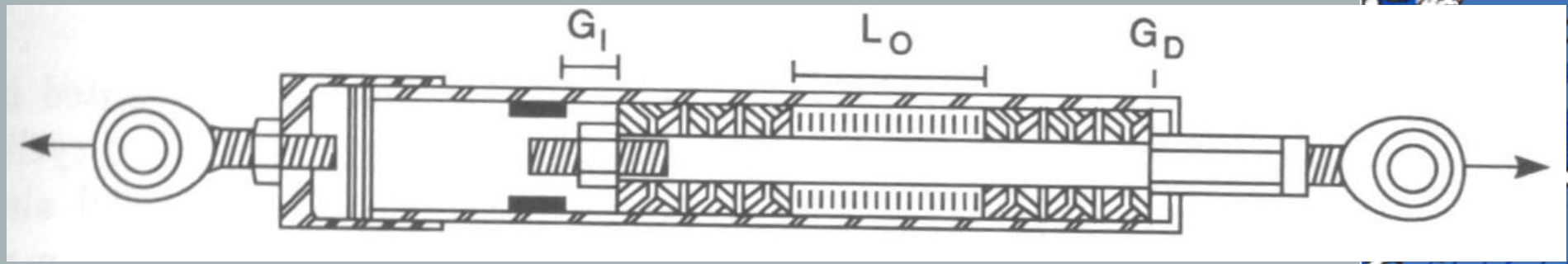




(Skinner)

Energy Dissipating Restraint

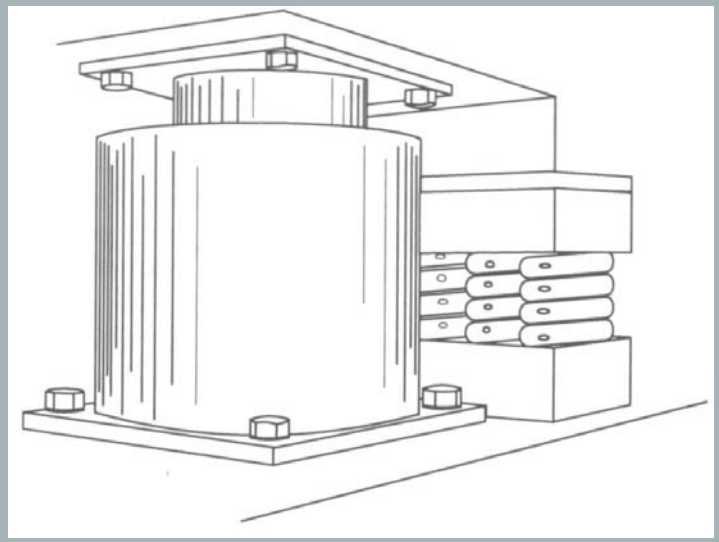
- *Friction Damper*



(Soong)

Base Isolation System

- *Helical Springs*
- *Cylindrical Pot Fluid Dampers*



(Soong)

Edo-Tokyo Museum

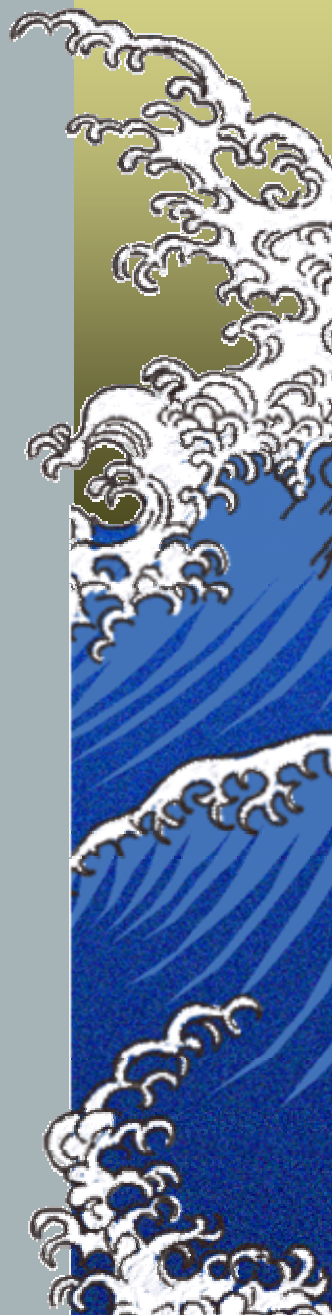
Tokyo National Museum

EQ Preparation: Museums

Edo-Tokyo Tokyo National

Japanese Seismically Isolated Buildings

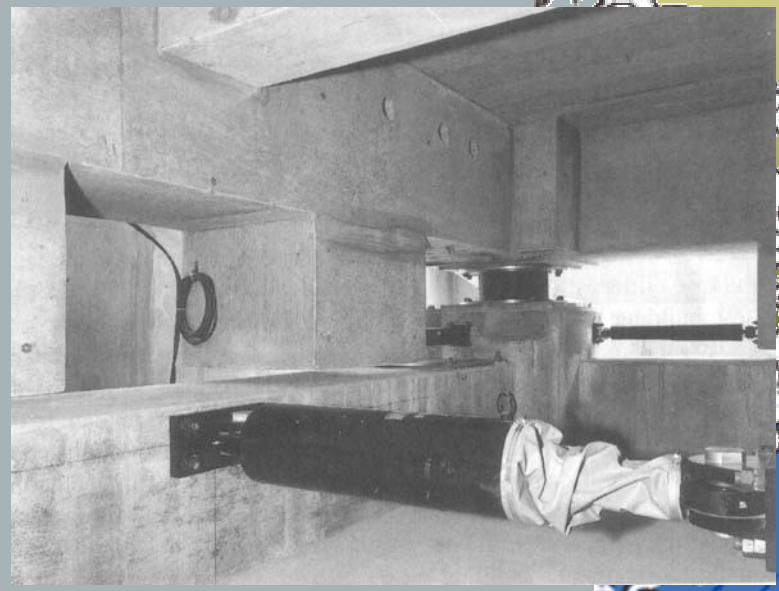
- *Elastomeric bearing*
- *Lead-rubber bearing*
- *High damping rubber bearing*
- *Sliding system*
- *Steel, viscous, friction, or lead damper*
- *Rubber spring*
- *Combinations*

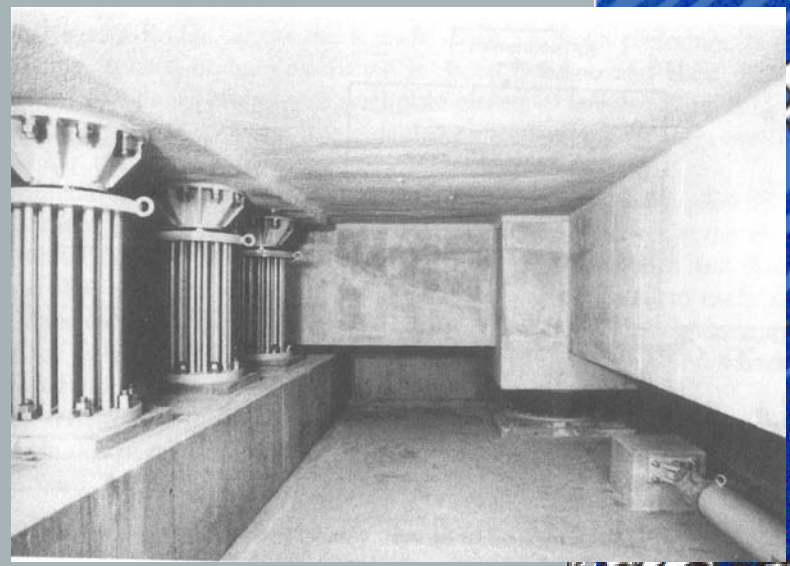


Combination Systems

- *Oil dampers and laminated-rubber bearings (Toboku University test structure)*
- *High-damping rubber bearing, steel dampers, and oil dampers in basement of Bridgestone Building, Tokyo*

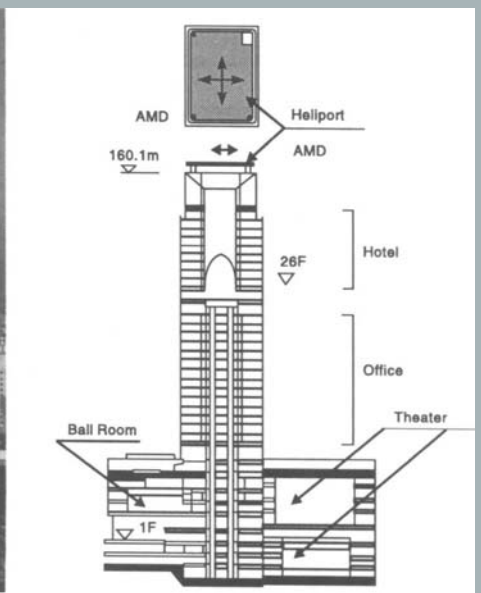
(Skinner)

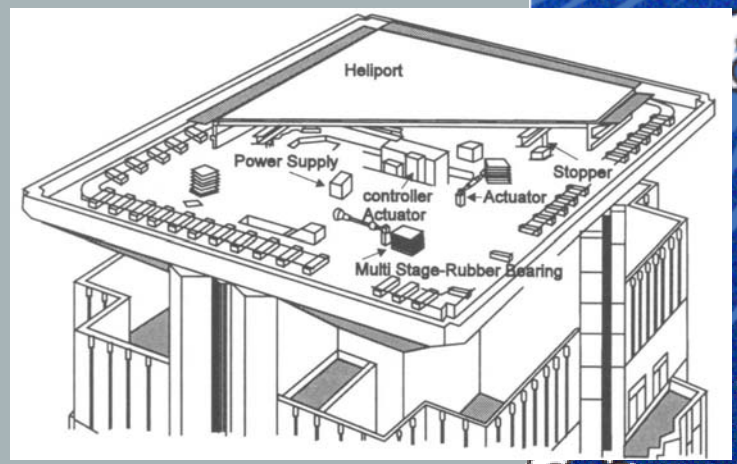




Hankyu Chayamachi Building, Osaka, Japan

- *Hybrid Tuned Mass Damper*
- *34 stories, 1991*
- *Mass damper@ roof, Heliport = mass for only transverse motion, on rubber bearings*
- *Active Control through hydraulic actuators*

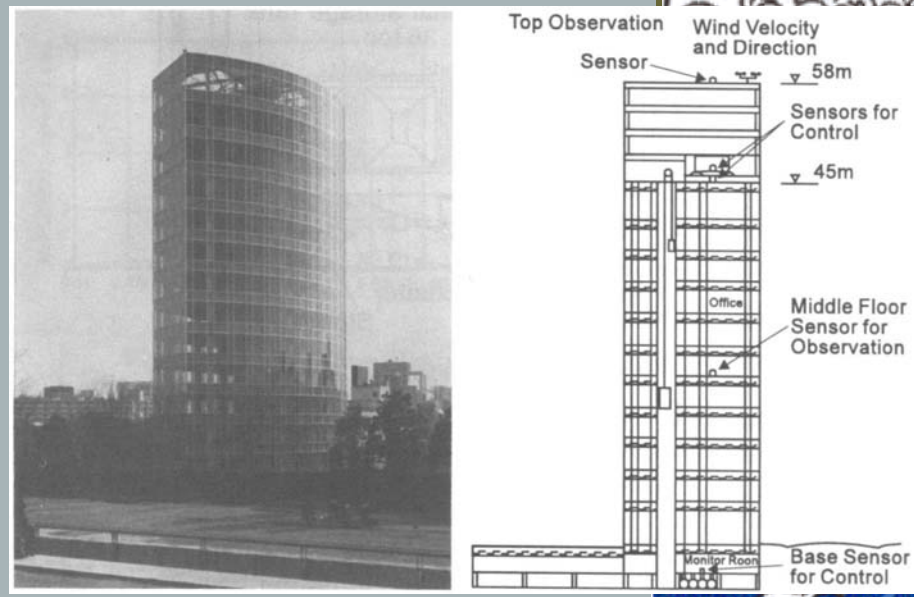




(Soong)

Sendagaya INTES Building, Tokyo, Japan

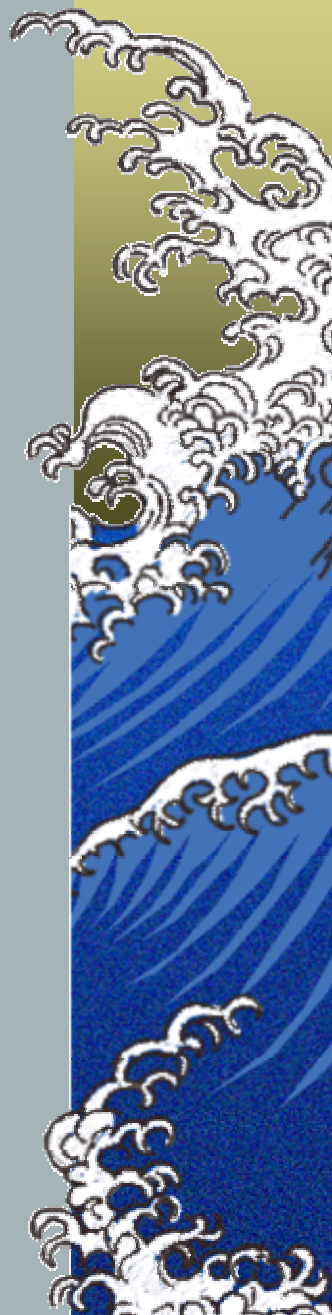
- *Hybrid Mass Damper System*
- *1991*
- *Mass damper@ 11th floor, 2 ice storage masses for both transverse and torsional motion, on rubber bearing*
- *Active Control through hydraulic actuators*



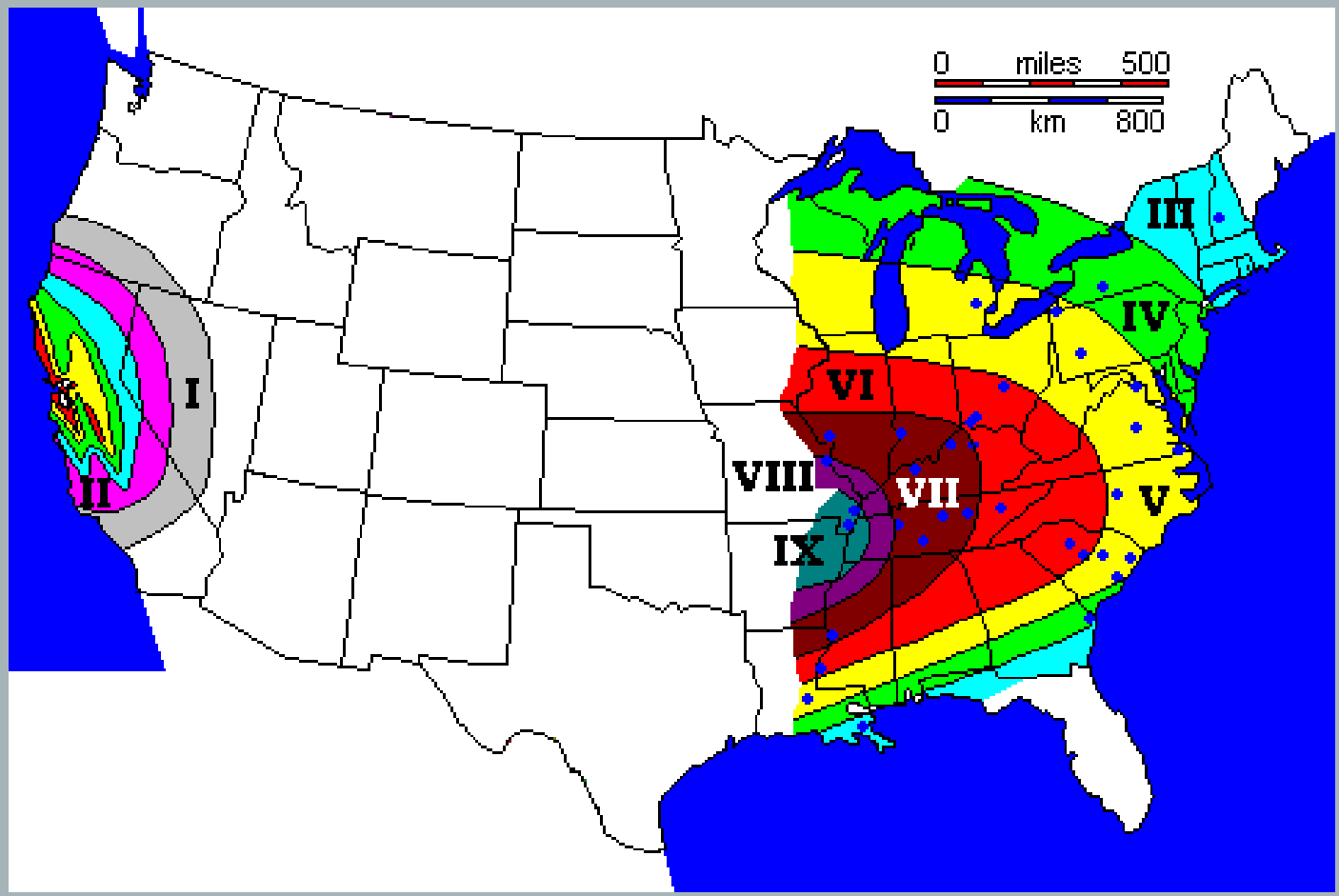
(Soong)

References

- *J. M. Kelly, Earthquake-Resistant Design with Rubber, Springer, 1997.*
- *R. I. Skinner, W. H. Robinson, and G. H. McVerry, An Introduction to Seismic Isolation, Wiley, 1993.*
- *T. T. Soong and G. F. Dargush, Passive Energy Dissipation Systems in Structural Engineering, Wiley, 1997.*



What about me?

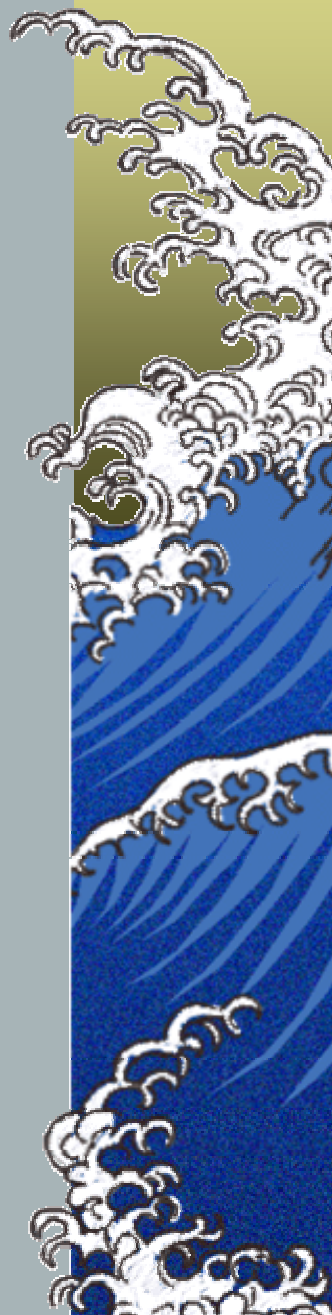


- *See Dr. Mullen, CCEP*

Miscellaneous Other Items

- *Water*
- *Gadgets*
- *Early tools, structures*
- *Transportation, commuting*
- *Architecture*
- *Construction, bridge*

See my website!



Water Resources: Canals

Akihabara

Tamagawa Josui

- Diverted water from the Tamagawa River for thirsty Edo in 1653
- >40 km to Yotsuya in Tokyo

Gadgets


止
おしり
ビデ
水勢
準備中
STOP
SPRAY
BIDET
WATER PRESSURE
STAND BY


おしり
ビデ
SPRAY
BIDET

Other Gadgets

Early Tools

- *Balance*
  - *For money*

Early Tools Cont.

- *Straight Line Machine*
  - *Sumi-Tsubo, Ink Stand*
  - *Carpenters, masons, construction workers*
  - *Inked string is snapped to transfer ink*

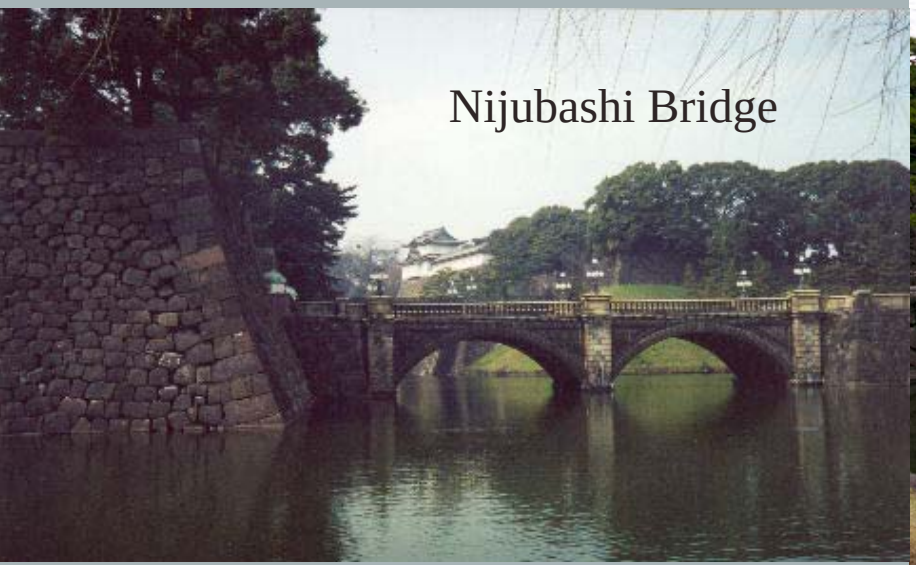
Early Tools Cont.

- *Crane Pulleys*

Imperial Palace Walls

- *With moat*
- *Without mortar*

Imperial Palace

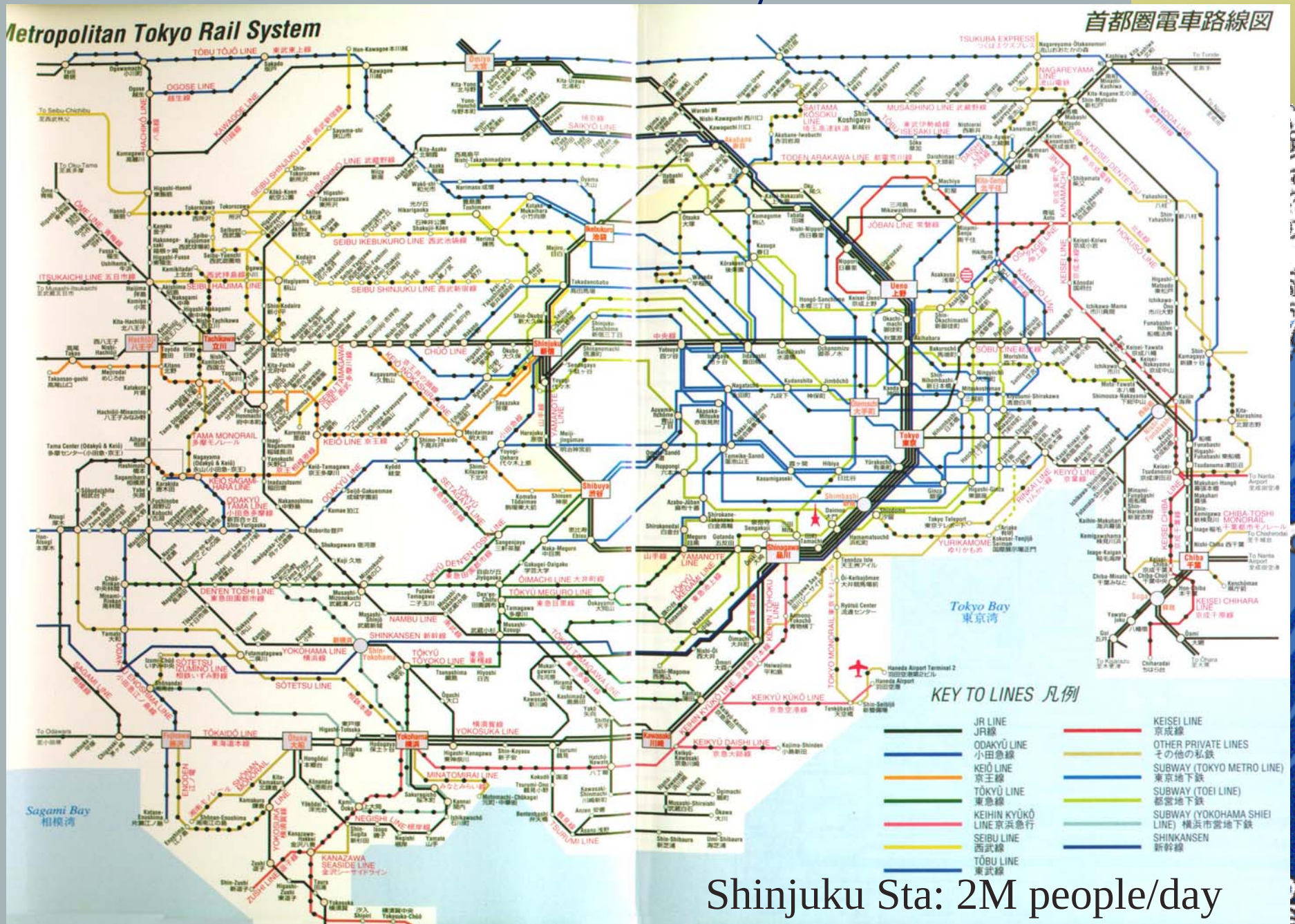


Nijubashi Bridge

Bicycle Lots

Parking Enforcement Officers

Commuter Rail System



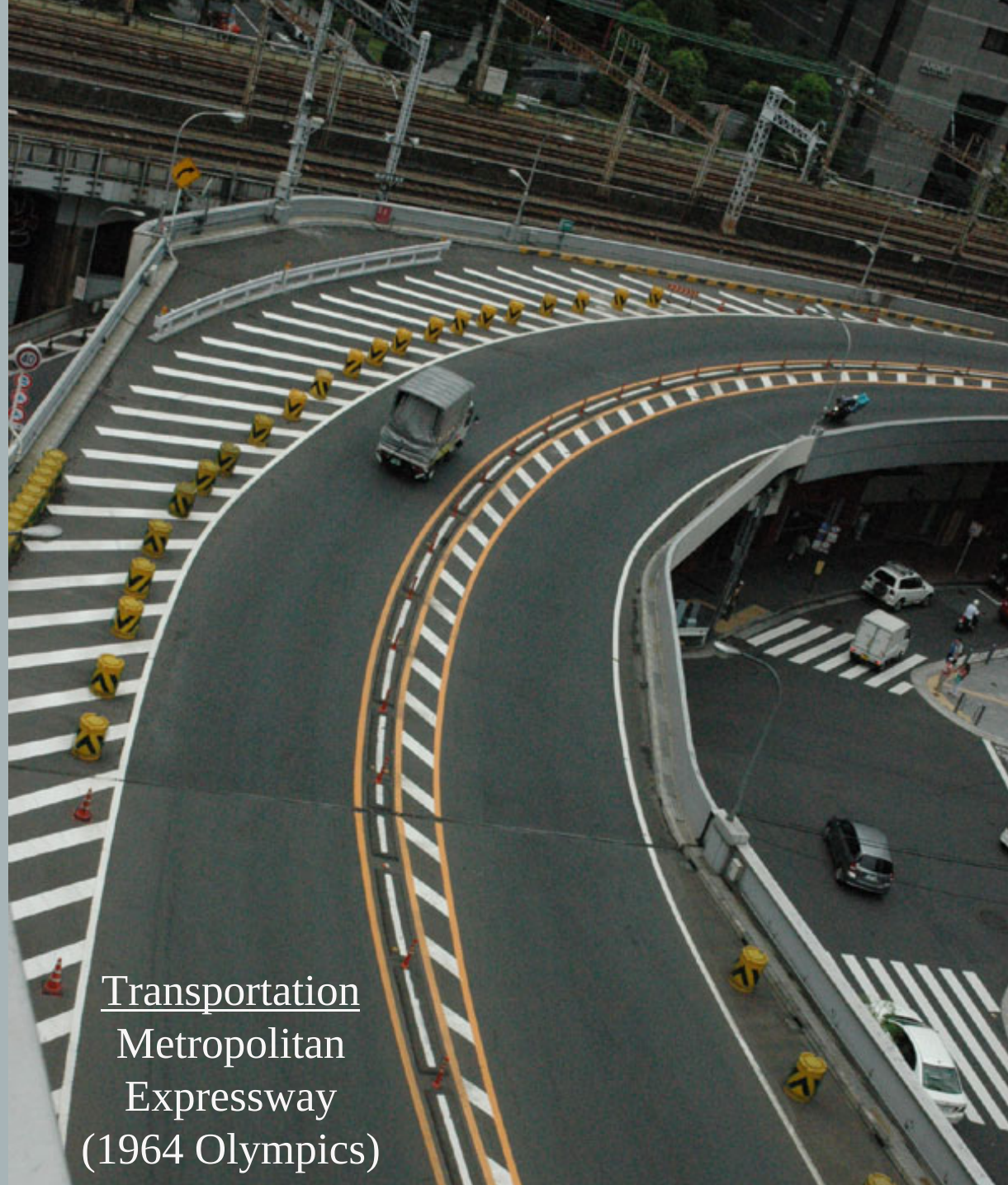
Shinjuku Sta: 2M people/day

Trains

東南口
South East Exit
1·2
りんかい線
1·4
埼京線
1·4
湘南新宿ライン
3·4
成田エクスプレス

12
中央線（快速）
Chūō Line (Rapid)
中野・立川・高尾方面
for Nakano, Tachikawa & Takao
快速 19:52 高尾
快速 19:57 高尾
高尾までの停車駅

Transportation



Transportation
Metropolitan
Expressway
(1964 Olympics)

- *Variety*
- *New with Old*

DoCoMo Sumida Building (2004)
Steel, concrete, RC
27 Fl. above, 2 Fl. below ground
→

Architecture

Other Structures

Swedish Embassy
(1990)
RC, 8 Fl. above,
2 Fl. below
ground
→

Tokyo Station

Rear

Opened in 1914.
Japan's main train station.
Numerous underground tracks.
2 dome roofs, damaged in WWII, repaired with slat-style roofs

Front

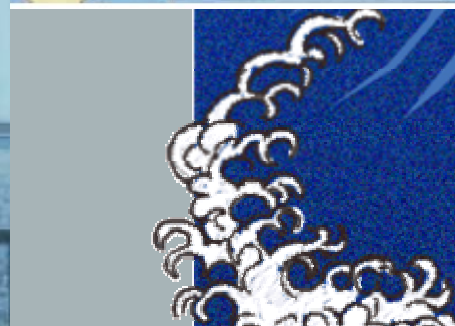
Destruction and Construction

Reinforcements

Tokyo Bay Bridge (2010)

- *2.9km long*
- *part of 4.6 km roadway*
- *Bridge High Performance Steel (BHS)*

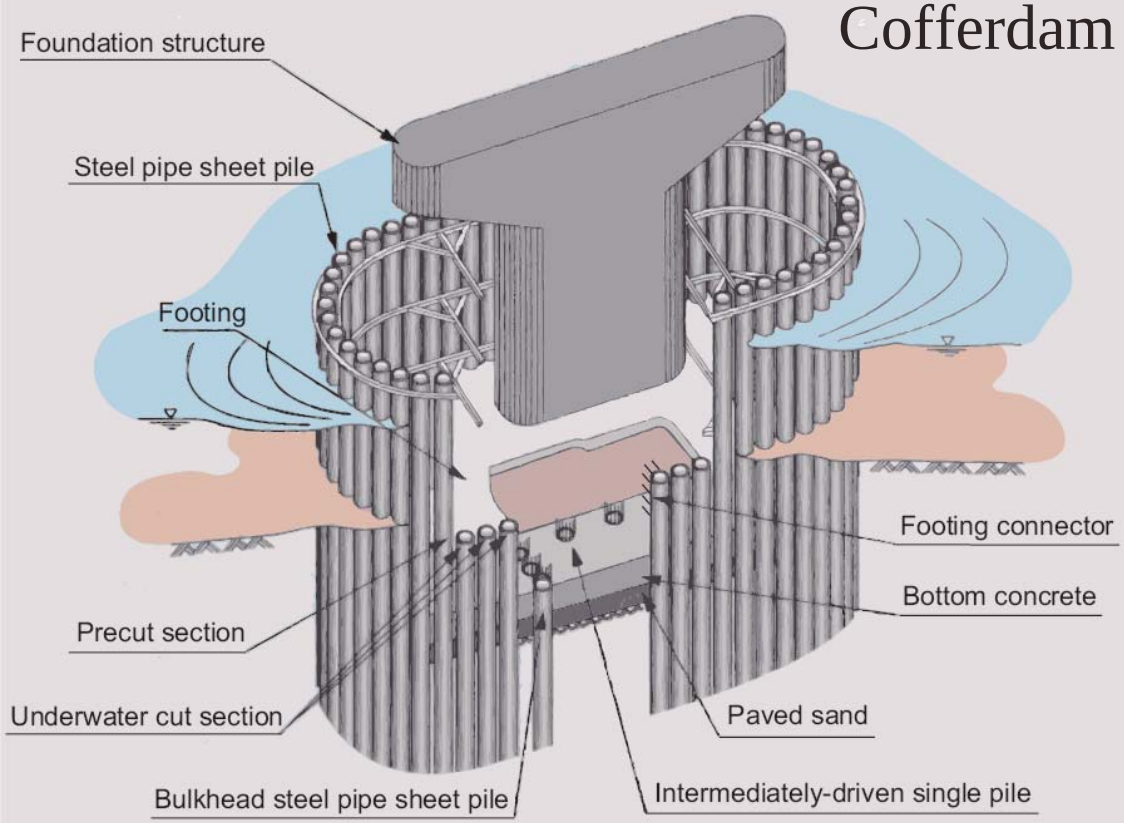
Artist's Concept



Tokyo Bay Bridge Cont.

Photo 2 Steel pipe sheet pile foundation

Cofferdam



Thank you!

Hase Kannon Temple , Kamakura