2007 PEER Seismic Design Competition

Essential Earthquake Engineering in 45 minutes
COMPETITION BACKGROUND

- Held annual at the National EERI Meeting
  - The 2007 was held at the Universal Hilton in LA
  - The 2008 will be held in New Orleans
COMPETITION BACKGROUND

- Economic Performance Evaluation
  + Rentable Area in Building as Revenue
  + Land and Structural Cost (footprint and weight)
  + Seismic damage cost as a function of performance
    - Structural damage cost as a function displacement between roof and ground
    - Equipment damage cost as a function of roof acceleration
2007 TEAM AND MODEL

- 5 Team Members
  - Joe Henry
  - Josh Lehr
  - Sarah Martin
  - Beth McNair
  - Jeremy Mikkelsen
2007 TEAM AND MODEL

- Cost sensitivity analysis
- Maximize total floor area
- Simple geometric architecture
- Lightweight
- Super stiff in order to be on the left side of response spectrum
EARTHQUAKE ENGINEERING

- Basic SDOF System without damping

\[ \frac{k}{2} \]

\[ m \]

\[ \frac{k}{2} \]
\[ T = \frac{2\pi}{\omega} \]

\[
\omega = \sqrt{\frac{k}{m}}
\]
Stiffness and Mass drive the natural frequency of structures

\[ \omega = \sqrt{\frac{k}{m}} \]
Seismic Design Competition

RESPONSE SPECTRUM

- Heart of structural dynamics
- Defines maximum response of simple structures of specified inputs

Ground Motions

Forces

FBD

Acceleration, Velocity, and Position as a function of time

Take the maximum value and plot verses natural frequency
Northridge
Displacement Component of Response Spectrum
(%5 Damping)
Northridge

Velocity Component of Response Spectrum

(%5 Damping)

Max Velocity (meters/sec)

Period T, (sec)
Northridge
Acceleration Component of Response Spectrum
(%5 Damping)
EARTHQUAKE ENGINEERING

Natural Frequency
Stiffness & Mass

Damping

Displacement $P$, (meters)
Period $T$, (sec)
Spectral Acceleration vs. Period

- Kobe
- El Centro
- Northridge

Acceleration (m/s²)

Period (s)
Effective Mass is the mass of the upper 50%
+ 10.25 lbs = 0.027 lb sec^2 / in

Stiffness is computed/estimated
+ 30 lbs/in

Thus \( \omega = 0.03 \) and
+ \( T = 0.005 \) seconds
NORTHRIDGE PREDICTIONS

- $T=0.005 \text{ seconds} \Rightarrow$
- Displacement = .002 m, Acceleration = 12 m/s$^2$
NORTH RIDGE TESTING

- Peak Roof Acceleration $1.5125g = 14.8 \text{ m/s}^2$
- Peak Relative Displacement $0.3042 \text{ in} = 0.008 \text{ m}$
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<tr>
<th>Team</th>
<th>Building Cost</th>
<th>Cost Rank</th>
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<th>Seismic Cost</th>
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LESSONS LEARNED

- Vertical Discontinuity
- Connections
- Member Continuity
Seismic Design Competition 2007
LESSONS LEARNED

- Properly size the damping system
- Full scale tests are good too
LESSONS LEARNED – TEST TO FAILURE

- Localized support at loading locations
- Vibration Effects
- Redundancy in support (lateral and gravity) was good
QUESTIONS?

DON’T FORGET TO SIGN UP IF INTERESTED FOR NEXT YEAR’S TEAM!