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WEB SESSIONS

Performance-Based Seismic Design of Tall Buildings: A World View

by

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WEB SESSIONS

Performance-Based Seismic Design: International Best Practices

October 24, 2012

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Ron Klemencic, President
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Eight Countries Represented

- Australia/New Zealand
- Chile
- China
- Indonesia
- Japan
- Korea
- Philippines
- USA

Best Practices and Observations

- Code Requirements
- Definition of Seismic Demand
- Performance Objectives
- Modeling Procedures
- Foundation Interaction
- Damping
- Gravity Load-Resisting Systems
- Non-Structural Systems
- Review Procedures

Code-Based Seismic Design

- All countries have codes that cover basic seismic design requirements

- **Minimum acceptable lateral strength and stiffness**
- **Minimum acceptable detailing practices**
- **Required attachment strength and displacement capacity of nonstructural components**

Performance-Based Seismic Design

Required for Tall/Irregular Buildings

China and Japan

Alternate Design Approach

Indonesia, Philippines, USA

Consistent Goals of PBD

- A "decision maker" states a desire that a building be able to "perform" in a certain way:
  - **Protect life safety**
  - **Minimize potential repair cost**
  - **Minimize disruption of use**
- The "engineer" uses his or her skill to provide a design that will be capable of achieving these objectives

Definition of Seismic Demand

Performance-Based Design

- Frequent
  - **Commonly around 50 year return period, Except China…. Approximately 500 year**
- Extremely Rare
  - **Commonly 1,000 to 2,500 year return period**

Code

- Intermediate (Design Level)
  - **Commonly around 500 year return period**

Performance Objectives

Ground Motion
x% - 50 years

Performance Level

- ***Design Hazard (earthquake ground shaking)***
- ***Acceptable Performance Level (maximum acceptable damage, given that shaking occurs)***

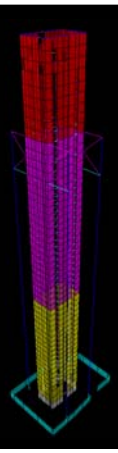
Performance Levels

Operational | *Immediate Occupancy* | *Life Safety* | *Collapse Prevention*

Frequent EQ | **Intermediate EQ** | **Extremely Rare EQ**

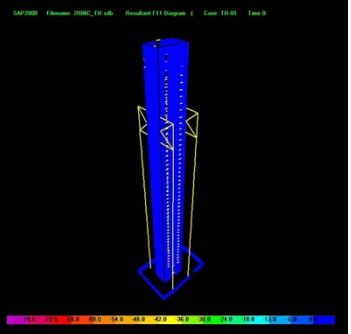
Computer Models

- Frequent and Intermediate (Design Level) EQ
  - **3D linear elastic model**
  - **Used to initially proportion elements**



Computer Models

- Extremely Rare EQ
  - 3D non-linear model
  - Dynamic (Response History) Analysis most common
  - Static (Push-over) also used in Chile



Foundation Interaction

- Commonly not considered
- When considered, idealized as springs and dashpots(dampers)
- Most commonly considered in Japan

Damping

- 2.5% typically considered at Service Level, except for China where 5% is considered.
- 2 – 3% Rayleigh Damping considered at MCE Level due to contribution of hysteretic damping
- China considers 5% damping at MCE Level

Gravity Load Resisting Systems

- Significant differences in approach
- China and Japan consider integral and secondary systems – not a “gravity only” system
- Other countries consider gravity elements separately and evaluate deformation compatability

Non-Structural Systems

- Commonly not addressed, except in Japan

Peer Review

- Commonly performed by a panel of experts
  - Knowledge of seismicity
  - Practicing engineering experience
  - Academic expertise in current seismic design

Summary

- Performance-based Seismic Design allows for cost-savings and better understanding of the building's performance.