

# An Introduction to Earthquake-Resistant Design

Stephen Mahin

*Nishkian Professor of Structural Engineering  
University of California at Berkeley  
777 Davis Hall  
693-6972; mahin@ce.berkeley.edu*



CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2008

©UC Regents

1-1

# The Earthquake Challenge

- ❖ Earthquakes provide one of the most challenging problems facing the structural engineering profession
- ❖ Important social and economic problem
- ❖ Field is rapidly changing
  - ✓ Changing demands by society
  - ✓ New tools for design and analysis
  - ✓ New technologies
- Basic concepts and tools relevant to design to resist other forms of natural and human-induced hazards

→ Critical thought  
→ Creative thought

← Our focus is to be integrative and synergistic

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2008

©UC Regents

1-2

# Today

- ❖ Course Organization
- ❖ Sources of Earthquake Damage
- ❖ Trends in Earthquake Engineering
  - ✓ Evolution of building codes
  - ✓ Genesis of performance-based approaches to earthquake engineering
- ❖ Preview of the Course

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2008

©UC Regents

1-3

# Course Organization

## Contact Information

- ❖ Instructor:  
Stephen Mahin  
777 Davis Hall, 643-6972, mahin@ce.berkeley.edu  
Office Hours: Tentatively, Tu & Th 1-2  
or by appointment
- ❖ Teaching Assistant:  
Jeffrey Hunt  
jphunt@ce.berkeley.edu  
504 Davis Hall  
Office Hours: TBD

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2008

©UC Regents

1-4

## Course Organization

### Lectures

Tu-Th 11 AM -12:30 PM  
534 Davis Hall (may change)

### Review and Discussion Session

- ❖ Weekly session with Graduate Student Instructor or Professor.
- ❖ Clarify important points in class or carry out examples.
- ❖ Help with homework assignments.
- ❖ Time slot to make up missed classes.

→ Wednesday, 4-6 pm, 3113 Etcheverry Hall

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-5



## Course Organization

### Prerequisites

- ❖ Advanced course in structural analysis (CEE 220/121)
- ❖ Course in structural dynamics through modal analysis and use of linear response spectrum techniques for multiple degree of freedom systems (CEE 225/125).
- ❖ Some design background.
- ❖ Some familiarity with simple plastic analysis (e.g., CE 220).

### Questions on student background:

- ❖ Capacity design concepts (CE 244) and simple plastic analysis (CEE 248)?
- ❖ Computer tools? FEDEAS, RAM, SAP, ETABS, OpenSees, CEE 221?

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-6



## Required reading from text

- ❖ *Earthquake Engineering: From Engineering Seismology to Performance-Based Engineering*, Yousef Borzorgnia and Vitelmo Bertero, Eds., CRC Press, 2004

❖ Available at half price at book store

### Assignment

✓ Skim Ch. 1

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-7



## On-Line Course Resources

Course notes, assignments, handouts, review questions, and so on will be posted on-line.

→ Precise URL will be announced later

### Web-based applications:

- ✓ Attenuation Relationships, Elastic Response Spectra, Modified Spectra for various factors (e.g., ductility, damping, etc.)

<http://peer.berkeley.edu/~jrodgers/>

Note: This site is not currently maintained other than for these applets



CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-8



## FEMA References

FEMA publications available for free by downloading from the web or calling 1-800-480-2520

- ✓ NEHRP Guidelines for the Seismic Rehabilitation of Buildings (FEMA 356), FEMA/ASCE, Washington DC, 1999. **(Required)**  
[http://www.degenkolb.com/0\\_0\\_Misc/0\\_1\\_FEMADocuments/fema356/ps-fema356.html](http://www.degenkolb.com/0_0_Misc/0_1_FEMADocuments/fema356/ps-fema356.html)
- ❖ The 2000 NEHRP Recommended Provisions For New Buildings And Other Structures (FEMA 368) FE14A, Washington DC, 2000,  
<http://www.bssconline.org/NEHRP2000/comments/provisions/>
- ❖ Seismic Evaluation and Upgrade Criteria for Existing Welded Steel Moment-Frame Buildings (FEMA 351), Specifications and Quality Assurance Guidelines for Steel Moment-Frame Construction for Seismic Applications (FEMA 353), Seismic Design Criteria for New Steel Moment-Frame Buildings (FEMA 350), FE14A, Washington DC, July 2000. <http://www.fema.gov/library/prepandprev.shtm#earthquakes>

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-9



## Useful References

### Various Technical Papers

- ✓ On Research in Engineering Library
- ✓ From course website or other provided URLs.

### Frequent reference to:

- ✓ "Structural Dynamics and Earthquake Engineering," A. Chopra, Prentice Hall, 2000.

### Reference Texts (for self-study - see syllabus):

- ✓ "Earthquake Engineering Handbook," W-F. Chen; C. Scawthorn, CRC Press, 2002.
- ✓ "Seismic Design Handbook," F. Naeim, 2nd ed., Kluwer Press, 2001.
- ✓ "Earthquake Geotechnical Engineering," S. Kramer, Prentice Hall, 1995.

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-10



## Important Sources of Information

### ❖ National Information Service for Earthquake Engineering <http://nisee.berkeley.edu>

- ✓ Library, located at Pacific Earthquake Engineering Research Center, Richmond
- ✓ Computer applications- Provides non-proprietary computer software and ground motions library

### ❖ Earthquake Engineering Research Institute, Oakland, CA - <http://www.eeri.org>



CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-11



## Nonlinear Analysis of Structural Systems

Download: <http://www.ce.berkeley.edu/~hachem/bispec/index.html>

### Bispec

- ✓ Single-DOF systems subjected to one or two components of one or more earthquake records
- ✓ Response spectra
- ✓ Animation
- ✓ Online and downloadable help manuals

Other programs (NONLIN, CAPP, ETABS, SAP) will be made available later

CEE 227 - Earthquake Engineering

U.C. Berkeley

Spring 2006

©UC Regents

1-12

