University of California at Berkeley
Civil and Environmental Engineering

Instructor: Stephen A. Mahin
Spring Semester 2009

CEE 227 -- Earthquake Resistant Design

General Information

Course Objectives

This course integrates information from various engineering and scientific disciplines in order to provide a rational framework for the design of earthquake-resistant structures. As such, the course touches upon pertinent information from engineering seismology, geotechnical engineering, economic, risk and reliability theory, sustainable development, and architecture in addition to advanced topics related to structural dynamics, analysis and design. The focus of the course is on building structures, but general issues are covered related design of bridges, industrial facilities and other types of structures that are allowed to respond in the inelastic range in the event of a major earthquake. The course emphasizes understanding the fundamental factors that influence and control the response of such structures, establishing a performance-based framework with which to assess seismic response, selecting project appropriate structural systems, configurations and proportions, and developing effective, but simplified, design procedures capable of reliably achieving specified performance goals.

Course Outline

1. Introduction. -- Basis of earthquake engineering design philosophies: role of uncertainty and the management of risk, an 'ideal' approach and some practical simplifications, limit state approaches, approaches adopted in current and emerging building code provisions. Special design considerations when permitting inelastic structural response are highlighted; limitations of historic analysis-based design approaches and introduction to "capacity design" concepts. Establishing a basis for performance-based earthquake engineering. Earthquake engineering issues relevant to sustainable development.

2. Engineering Characterization of Earthquake Ground Motions. -- Sources of earthquake ground motions; measures of earthquake intensity and damage potential; effects of local soil conditions on ground shaking; engineering estimation of ground motion characteristics based on deterministic and probabilistic approaches.

3. Response of Simple Structural Systems to Different Types of Ground Motion. -- Assessment of the effect of structural system and ground motions on the response of simple single- and multiple-degree-of-freedom systems. Emphasis on identifying desirable characteristics of structures for various types of ground shaking, and on developing simplified procedures suitable for estimating seismic response during the preliminary design process.

4. Development of Design Earthquakes for Linear Structural Response. -- Identification of critical parameters -- influence of local soil conditions and structural damping; development of design spectrum.

5. Development of Design Earthquakes for Nonlinear Structural Response. - Identification of critical parameters -- influence of local soil conditions, viscous damping, duration of shaking, nonlinear mechanical characteristics of the structure, and geometric nonlinearities; development of design spectra from ground motion and structural characteristics; displacement estimates; alternative spectra formats; extension of design spectra to multi-degree of freedom systems.

6. Analytical Procedures for Preliminary/Conceptual Design and Proportioning of Structural Systems. – Review of simple plastic theory; estimation of the maximum strength and deformation capacities of structural systems; simplifications for design of multistory structures; application of capacity design methods. Emphasis on ductile moment-resisting frames and braced frames. Methods discussed to control displacements and other response parameters of structural interest.

7. Code Related Issues. -- Basis and limitations of current code provisions for structural analysis and design. Future trends. Nonlinear static pushover procedures for evaluation of new and existing structures, development of target displacements.

8. Basic Performance-based Evaluation and Design Issues. -- Lessons from past earthquakes; quantification of performance objectives and levels for seismic resistant design; Selection of analysis procedures; numerical modeling of structural systems. Estimation of fragility functions and quantifying the confidence of a structure's ability to achieve a targeted performance objective. Current and emerging guidelines for the evaluation of existing and new structures.

9. Applications. -- Steel (and to a lessor extent reinforced concrete) details to insure member and connection ductility; basic design considerations for moment-resisting frames and concentrically braced frames. Application of concepts to structures employing seismic isolation or utilizing supplemental energy dissipation devises. Self-centering systems.

Prerequisites

Students are expected to have a background in structural analysis and structural dynamics. A basic understanding of inelastic structural analysis is required. Courses such as CEE 220 and CEE 225, or their substantial equivalent, satisfy this requirement. Students uncertain about the adequacy of their preparation should contact the instructor.

Course Organization

Lectures: Tu-Th 11 AM -12:30 PM; 534 Davis Hall
Discussion Session: time and location TBD

The weekly discussion session will be devoted to discussion of the conceptual and analytical approaches presented in the class and for help in solving homework assignments. Make up lectures will be, to the extend possible, held in the time slot assigned to the discussion section. The time of the discussion session may be changed to make it more convenient for students to attend.

Exams: There will be two 80 minute long midterms. There will be no final exam, but a final term project will be required.

Term Project: The term project may be done individually or in groups of two. The intent of the term project is for the student to undertake a significant, but short project related to the design or analysis of structures, development of software to assist in the seismic resistant design of structures, or other application of the material learned in the course. The choice of topic is left to the student, but instructor approval is required. A separate handout will describe the scope and requirements for the term project. Larger groups are possible, but require special prior approval by the instructor.

Grades: Grades will be based on performance on homework assignments, several midterm quizzes, and a final term project, according to the following approximate weights: 25%, 40% and 35%.

Contact Information

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Office Hours:	TuTh 12:45-2:00 PM	TBD

Course Web Site

A website has been developed for the class. It provides a means of accessing copies of class notes prior to the lecture (please download these if you would like to have them during the lectures), copies of handouts, homework assignments and solutions, references, practice exams and study questions, various photos and movies, and links to various other web sites related to earthquake engineering. There is also a class blog for timely communication of late breaking information about the class. The website can be accessed at:

URL:	http://web.mac.com/smahin/CE227-09/CE227.html
User Name:	ce227
Password:	Berkeley