Georgia Institute of Technology *Department of Civil and Environmental Engineering*
Spring Semester, 2003 Dr. Reginald DesRoches
(w) 404 385-0826 Room 326 Mason
reginald.desroches@ce.gatech.edu *http://www.ce.gatech.edu/~rdesroch/*

CE 6541 EARTHQUAKE ENGINEERING

Lecture Tu,Th 9:30-11:00 am, Room 316 SEB

Course Objectives
This course integrates information from various engineering and scientific disciplines in order to provide a rational basis for the design of earthquake-resistant structures. As such, the course touches upon pertinent information from engineering seismology, geotechnical engineering, risk and reliability theory and architecture in addition to advanced topics related to the dynamics and the analysis and design of structures. The focus of the course is on buildings, bridges, industrial facilities and other types of structures that may in the event of a major earthquake be allowed to respond in the inelastic range. The course emphasizes a theoretical understanding of the fundamental factors influencing and controlling the response of these structures, and on the development of effective, but simplified, design procedures capable of achieving specified performance goals.

Prerequisites: Students are expected to have a background in structural analysis, mechanics, structural dynamics, and design in either reinforced concrete (preferred) or steel. A basic understanding of inelastic structural analysis is required. Courses such as CE6501, CE6510, and CE6521, CE6551, or their equivalent, satisfy this requirement.

Computer: An important part of the course is solving computation problems. We will use Matlab, NONLIN, NONLIN Pro, and other programs on the Civil Engineering PC's on second floor in Mason. All files needed for the class will either be on the computers or will be sent to you via e-mail.

Assignments: Assignment of problems related to the lecture material will be made regularly. The problems may be theoretical, computational, or design-oriented. Please be concise and neat in submitting solutions. You are encouraged to work together, however, you must submit your own assignments.

Exam. There will be one 3-hour midterm in about the eighth week of classes.

Comprehensive Design and Analysis Project. Another requirement of the course is that you complete a term project. This year's project consist of a comprehensive seismic design and analysis of a multi-story building. This project will be in collaboration with the Geotechnical Earthquake Engineering class (CEE6445), taught by Dr. Rix. Each group will consist of 5-7 members (split *approximately* evenly between CEE6445 and this class). You will asked to perform a complete design of a reinforced concrete building using the 2000 IBC. The design will consists of seismic hazard analysis and development of spectra and ground motion, design and detailing of members, and analysis of the structure. The project requirements are a 30 minute oral presentation during the last 2 days of class and a written report submitted on the next to last day of class.

Grading. The course grade will be determined by *homework*, 35%, *midterm*, 35%, and *project*, 30%. The following grading scale will be used as an approximate guideline: 90-100 A, 80-90 B, 70-80 C, 60-70 D.

Office Hours. Monday, Wednesday 3:30-5:30, Room 326 Mason.
Teaching Assistants: Bryant Nielson (Room 511 Mason), Jason McCormick (Room 325 Mason)

Book: Although there is not an official textbook for this course, the Textbook by ***Chopra, Dynamics of Structures***, will be used significantly throughout this course.

Outline (Tentative) — Date

I. INTRODUCTION **(Tu - 1/7)**

A. Overview of Course
B. Overview of Earthquake Engineering, lessons learned
C. Basic Guidelines for designing damage tolerant structures

II. SEISMOLOGICAL ASPECTS OF EARTHQUAKE ENGINEERING (1) **(Th - 1/9)**

A. Causes of earthquakes, theory of plate tectonics
B. Global and regional seismicity
C. Plate tectonics and fault mechanisms
D. Seismic waves, elastic rebound, epicenter vs. hypocenter, locating EQ's
E. MMI, Richter, standardized damage, earthquake magnitude and energy

III. GEOTECHNICAL ASPECTS OF EARTHQUAKE ENGINEERING (2) **(TuTh - 1/14-16)**

A. Attenuation relationships, Ground motion parameters, Soil Properties
B. Deterministic and Probabilistic Seismic Hazard Analysis
C. Local Site Effects and Design Ground Motions, Liquefaction

IV. REVIEW OF STRUCTURAL DYNAMICS - EARTHQUAKE RESPONSE AND DESIGN SPECTRA (3) **(Tu- 1/21- Tu-1/28)**

A. Review of SDOF Dynamics; free vibration & response to harmonic loads
B. Review of MDOF Dynamics: EQM, mode shapes and frequencies, damping, direct solution, modal analysis

V. DYNAMICS (5) **(Th - 1/30- Th - 2/13)**

A. Time-stepping methods (linear and nonlinear)
B. Types of analyses, objectives
    - Time-history
    - Modal response history,
    - Response spectrum & Design Spectrum
    - Inelastic Response (constant ductility)
    - Equivalent static analysis procedures

VI. EARTHQUAKE CODES – DESIGN OF BUILDINGS (4) **(Tu - 2/18 - Tu – 2/27)**

A. IBC-2000 & 1997 NEHRP
B. Examples and Case Studies

SPRING RECESS (3/3- 3/7)

VII. REINFORCED CONCRETE (R/C) (2) **(Tu 3/11, Th-3/13)**

A. Principles of inelastic design for reinforced concrete structures
B. Capacity design concept
C. Flexural and shear strength
D. Confinement ductility
E. Seismic detailing, moment resisting frame members, beam-column joints, shear walls, current research.
F. Retrofitting of Concrete Structures

MIDTERM (Tuesday, 3/18: Afternoon Exam – 3 hour exam)

VIII. STEEL AND COMPOSITE DESIGN (Leon) (3) **(Th – 3/20 – Th- 3/27)**

A. Material behavior under cyclic loads
B. Structural systems: OMR, SMRF, CBF, EBF, and SSW
C. Flexural elements: plastic hinge behavior
D Axially loaded elements: braces
E. Flexural and axially loaded elements: beam-columns
F. Shear elements: panel zones and shear walls
G. Connections: FR welded and bolted; PR bolted
H. Code provisions: NEHRP and AISC
I. Composite construction

IX. EQ RESISTANCE OF MASONRY STRUCTURES AND REHAB OF BUILDINGS (KAHN) (1) **(Tu-4/1)**

A. Behavior of Unreinforced masonry walls: Inplane forces; Out-of-plane forces; Infilled Frame

B. Behavior of Reinforced masonry structures: Inplane forces, boundary elements, shear distribution; Out-of-plane forces; Infilled frames, connections; Wall-floor connections

C. Retrofit of Unreinforced Masonry Buildings: Wall-floor connections, joint anchors; Wall reinforcement techniques

X. An Introduction to Seismic Isolation (3) **(Th – 4/3, Th 4/10)**

A. Base Isolation – Theory

B. Base Isolation – Design (FEMA 273)

C. Examples

XI. Passive Energy Dissipation Systems **(Tu – 4/15 – Th – 4/17)**

A. Energy Balance

B. Hysteretic Dampers

C. Friction Dampers

D. Viscoelastic Dampers

E. Fliud Viscous Dampers

F. Shape Memory Alloys

Project Presentations (Tuesday-Thursday, 4/22 – 4/24 – 9:30-2:30)