



## **CE 599 Seismic Design of Structures**

**Units: 4**

### **Course Description**

We will learn the principles and techniques of earthquake resistant design of buildings and apply them to design a mid-rise office following the procedures commonly utilized by reputable structural engineering consulting firms. Basic understanding of steel design, R/C design and dynamic response of structures is presumed. During the length of the semester, the class functions as a typical design team in an office. Students function as project design engineers. In addition, each student may select a relevant topic of interest and make a PowerPoint presentation to the class at the end of the semester. We will be using contemporary structural engineering software such as ETABS and SAFE as used by prominent structural engineering consulting firms.

### **Learning Objectives**

Understand the various demands and actions imposed by seismic events on various structural systems and components. Distinguish between ductile and brittle behavior of various structural components and systems and develop the ability to design ductile structures to resist earthquake forces in life-safe manner with a low probability of collapse during very large and rare seismic events.

**Prerequisite(s):** Basic reinforced concrete and structural steel design knowledge

### **Course Notes**

Copies of lecture slides and other class information will be posted on Blackboard.

### **Technological Proficiency and Hardware/Software Required**

Students need to have the following computer hardware and software:

1. A PC (or Mac) with connection to Internet capable of running Windows operating system. You will install and maintain a variety of software on this PC. Therefore, using a public PC is not going to work. You may use Parallels, Vmware, Boot Camp, or other software to emulate Windows if you are using a Mac.
2. Microsoft Office (Word, Excel, PowerPoint) or compatible software.
3. A PDF file creation utility. Please note that a full version of Adobe Acrobat, although nice, is not necessary as there are several free or inexpensive PDF creation tools available for download on the Internet.

### **Required Readings and Supplementary Materials**

In addition to lecture handouts, students will be provided with online access to required readings and a wealth of other resources and references.

### **Description and Assessment of Assignments**

Students will form project groups and work on a seismic design project during the semester. Regular project progress reports are required as the project design progresses forward. There will be a mid-term exam and a final exam. A final detailed project report is required from each project group at the end of the semester and each student will make a presentation regarding their work on the project during the last day of classes.

## Grading Breakdown

The grading will be based on the quality of homework submissions and performances on the mid-term and final exams.

| Assessment Tool (assignments) | % of Grade  |
|-------------------------------|-------------|
| Mid-Term Exam                 | 20%         |
| Project Report                | 40%         |
| Project Presentation          | 10%         |
| Final Exam                    | 30%         |
| <b>TOTAL</b>                  | <b>100%</b> |

## Course Schedule: A Weekly Breakdown

1. Welcome to CEE-599: Overview of the projects we will be working on; governing codes and standards; project participation process; design office procedures from job procurement to final design; importance of good engineering and consequences of bad engineering; the tools of the trade; current practice versus current state of knowledge. Review of means of quantification of earthquakes; common earthquake damage mechanisms and how to avoid them.
2. Review of Seismic Hazard Analysis for Design: Deterministic and probabilistic seismic hazard analysis and their interpretations and implementations in seismic design codes and standards.
3. Preliminary Design of Structures: Back of the envelope calculations and rules of thumb for proportioning structural members and systems; preliminary sizing of steel and concrete beams; columns and various floor systems; formulas for estimating lateral displacements and drift control for moment frames; braced frames and walls.
4. Code Provisions for Seismic Design: ASCE 7 seismic design criteria; horizontal and vertical irregularities; occupancy and seismic design categories; design wind and seismic forces; static and dynamic distribution of forces; foundation issues; IBC load combinations for wind and seismic effects; special seismic loads and design coefficients;  $R$ ,  $I$ ,  $C_d$ , and  $\Omega_0$  factors; height limitations; site conditions; base shear and shear distribution over the height; diaphragm forces.
5. Design of Steel Special Moment Frame Systems: Review of past performance of SMRF systems; principles of SMRF design; pre-qualified connections; reduced beam section (RBS) connection; design of RBS systems; strong column - weak girder requirement; drift design; P- $\Delta$  effects and their importance.
6. Design of Concentric Braced Frame Systems: Description and types of Centrally Braced Frames (CBF); behavior of CBFs; AISC Seismic Provisions for Special CBFs; developing ductile behavior in CBF; overturning and overall stability; forces in beams, columns, and braces; design of connections; foundation issues
7. Design of Eccentric Braced Frame Systems: Description and types of Eccentric Braced Frames (EBF); behavior of EBFs; AISC Seismic Provisions for Special EBFs;

shear link behavior; link plastic rotations; proportioning EBFs; design approach for EBFs.

8. Design of Buckling Restrained Braced Frame Systems: Description and types of Buckling Restrained Braced Frames (BRB); behavior of BRBs; AISC Seismic Provisions for BRBs; developing ductile behavior in BRBs.
9. Design of Steel Special Plate Shear Walls: Description and types of Steel Special Plate Shear Walls (SPSW); behavior of SPSWs; AISC Seismic Provisions for SPSWs; developing ductile behavior in SPSWs.
10. Design of R/C Frames, Walls, and Coupled Walls: Behavior of R/C frames and walls; P- $\Delta$  effects and their importance; IBC and ACI 318 provision for seismic design and detailing of R/C frames and walls; significance of confinement; longitudinal and transverse reinforcement details; precast options; seismic detailing of slabs; strong column - weak girder requirement; columns supporting discontinued stiff members.
11. Seismic Design of Floor Diaphragms: The role of a diaphragm in a building; diaphragm classification; rigid, flexible, and semi-flexible diaphragms; collectors, chords and drags; diaphragm design procedures; diaphragm deflections; diaphragm modeling issues; potential diaphragm problems.
12. Seismic Design of Foundation Systems: Overview of foundation alternatives; design of spread footings; design of combined footings; design of grade beams; design of piles and pile caps; design of mat foundation; an introduction to soil-structure-interaction and its impact on response of buildings.
13. Analysis and Design of Seismic Isolated Structures: Development of seismic isolation worldwide; theoretical basis of seismic isolation; isolation system components, code provisions for seismic isolation; mechanical characteristics and modeling of isolators.
14. Analysis and Design of Structures with Energy Dissipating Devices (Dampers): Development of Energy Dissipating Devices (EDD) worldwide; various types of EDD and their characteristics; theoretical basis of use of EDDs; EDD components, code provisions for seismic isolation; mechanical characteristics and modeling of EDDs.
15. Post-Earthquake Safety Assessment of Buildings: The ATC-20 methodology for rapid and detailed evaluation of buildings following earthquakes and posting them as INSPECTED (green placard), RESTRICTED USE (yellow placard), or UNSAFE (red placard). We will also cover special procedures for evaluation of essential buildings (e.g., hospitals), evaluation procedures for nonstructural elements and geotechnical hazards.

## Statement on Academic Conduct and Support Systems

### Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

### Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University's educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at [osas.usc.edu](http://osas.usc.edu). You may contact OSAS at (213) 740-0776 or via email at [osasfrontdesk@usc.edu](mailto:osasfrontdesk@usc.edu).

### Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a

week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or [otfp@med.usc.edu](mailto:otfp@med.usc.edu)

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.