University of California at Berkeley
Civil and Environmental Engineering

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CEE 227 -- Earthquake Resistant Design

Introduction to Class "Archetype" Building

Most of the homework assignments this semester will be related to the design of a hypothetical structure to be constructed in Berkeley or the development and trial applications of simple tools that can be used in the design of such structures. The class homework assignment building is based on a archetype building widely used in the literature. The original building was intended to be located in Los Angeles, but for the purposes of this class we will assume it is to be built in Berkeley, on a level rectangular site, located on firm soil approximately 3 km west of the Hayward Fault and 28 km east of the San Andreas Fault. The Hayward fault is assumed capable of generating an earthquake with a Richter magnitude of 7.2 and a magnitude 8+ earthquake is expected eventually on the San Andreas Fault. There are a number of smaller faults in the area. Thus, earthquake loads are a major design consideration in the overall design of this structure. Additional information on the seismic environment will be provided later.

For our archetype building, we will assume the owner intends to use it as a high-technology research facility, rather than as a normal office building (as envisioned in the original design of the building). Specifically, the building will have mixed use, housing a variety of nanofabrication labs, high performance computer workstations for computer-assisted engineering as well as space for developing and prototyping advanced production systems. It will also house the corporate mainframe computer, which holds much of the company's proprietary software, intellectual property, and financial records. It also provides office space for the chief of the corporate research division. The company believes that a short shutdown of the building of a few days or possibly weeks would be acceptable under a rare event, but that a major shut down of three or more months would make them consider building their office in Austin, Texas rather than build it in a seismic zone. For truly rare events, they want to minimize but not necessarily avoid damage, but the costs of protecting their intellectual and capital investments in the building would have to be weighed against costs. Based on discussions with the owner, the design life of the structure may be assumed to be 50 years.

During the course of the semester, you will carry out a preliminary design of the structure using relatively conventional as well as more advanced procedures, and evaluate your design using a variety of analytical techniques. Because of the technological orientation of the client, and their active risk management program, this project allows for a lot of latitude in design. We will base our starting design upon a similar building designed for the company but for a different location (Los Angeles) using ASCE 7-05 (Minimum Design Loads for Buildings and Other Structures). It is now to be designed for Berkeley, meeting the minimum requirements of ASCE 7-05, but for the special performance requirements stipulated by the owner. In this class, we will use the concepts in FEMA 356 (ASCE 41-06) and other emerging PBEE procedures to evaluate and improve the performance of the structure to satisfy the owner's special requirements. You will see that some creativity is required to achieve an economical as well as safe structure that meets the owners expectations. We will examine how to do this in these problem assignments.

It will be assumed that the structure will be constructed from steel, and initially that it will be a moment-resisting frame. Other lateral load-resisting systems will be considered later (e.g., braced frames). If you are more comfortable using reinforced concrete, this would be acceptable. However, certain information (floor weights, etc.) will be specified for steel, and homework solutions will be worked out only for steel. We will focus on basic configuration, relative proportioning and sizing related issues, and not on detailing.

Basic Description of the Building

In addition to the information provided above, consider the following for the building. Additional information will be supplied later.

Building Footprint:	120 ft by 180 ft
Building height:	3 stories; no basement; plus small penthouse 30 ft by 60 ft. in plan.
Story height:	15 ft typical, including the penthouse
Column layout:	a basic 30-ft grid in both directions is considered
Structural System:	Special "ductile" moment frame in steel (see above comments and figures provided below)
Building weights:	Steel framing - as designed, but consider 10 psf as a reasonable Estimate since the structure needs to be redesigned. Decking - 3" metal decking with an additional 3-1/4 inch thick LWC fill. (42 psf, including 18 gage metal deck) Roofing - 7 psf average Ceiling - 3 psf Flooring - 3 psf Mechanical and Electrical - 7 psf on all floors, 50 psf average on floor within penthouse Partitions - 10 psf for seismic weight calculations, 20 psf for gravity load design Exterior cladding - Assume 20 psf of wall surface area on average for the entire building, including the penthouse. Gravity loads per foot on supporting members would be the tributary height (15 ft) times 20 psf. Lateral loads would be the same value except for the roof, where it would be 15'/2+4' (for parapet) Live loads - use UBC provisions for office occupancies - 50 psf (area reduction factors are permitted)

Based on these values, it has been estimated that the total weights of each floor are as follows (these values can be used in subsequent calculations of lateral loads and dynamic properties). The weight of the penthouse is included in the roof values given below.

Floor	Dead Load (kips) for computing seismic loads, including ½ of partition loading
Roof	1992 (including penthouse)
3	1942
2	1942

Soil Conditions: Stiff soil corresponding to FEMA 368/356 class D sites (or unknown conditions in ASCE 7)

Foundations: Spread reinforced concrete footings with allowable stresses of:

DL = 4 ksf
DL+LL = 6 ksf
DL+LL+E = 8 ksf

The plan and a longitudinal frame elevation are shown on the following page for the existing building in Los Angeles for which we are to design an enhanced Berkeley equivalent.

General Note on CEE 227 Homework Assignments:

Many of homework problems in this course are sequential in nature; that is, they build upon results obtained in prior solutions. For this reason, when you submit your assignments it is necessary for you to keep a copy of your solutions so you can work on the next week's assignment. Alternatively, you may base your next assignment on the solutions provided by the Teaching Assistant.

Generally, it is best to read the entire problem before starting a formal answer to the first part of the problem. Often, the various parts of the problem interact, so thinking about what is needed at the end of the problem will help define, focus and limit the scope of what you do on the earlier parts of a problem. Sometimes a later part simply requests you reiterate a prior answer in the context of the subsequent steps you have taken.

You will need to down load FEMA 356 as well as several other FEMA documents to do many of the problems.

Please note that questions asking you to compare, describe or briefly discuss results typically require only a VERY short (on the order of a sentence or brief paragraph) answer or one or more simple sketches.

If you are unclear about the intent of a problem or the solution strategy, please request clarification from the instructor or graduate student instructor.