DESIGN AND PERFORMANCE ISSUES RELATING TO HIGHER EDUCATION FACILITIES (UNIVERSITIES) 11

11.1 INTRODUCTION

University campuses generally consist of many different types of buildings, in a broad variety of sizes, housing many different functions. As a result, higher education facilities are, in many ways, a microcosm of the larger community. In addition to teaching classrooms, university facilities include auditoriums, laboratories, museums, stadiums and arenas, libraries and physical plant facilities, to name a few. As universities make decisions about the buildings that they construct, seismic considerations can easily be factored into the decision process.

The following are some unique issues associated with higher education facilities that should be kept in mind during the design and construction phase of new facilities:

- Protection of students, faculty and staff is a very high priority.
- Higher education facilities have a high daytime occupancy and some evening use, with reduced use in the summer months. Classrooms in particular often have high intensity usage.

- Closure of higher education facilities represents a very serious problem, and major college and university damage can have long-term economic and social effects.
- Ensuring the survival of records, whether in electronic or written form, is essential for continued operation.
- Protection of valuable contents such as library inventories, research equipment and materials is a high priority.

11.2 OWNERSHIP, FINANCING, AND PROCUREMENT

Higher education facilities are typically developed by the institution, which may be privately, state or local-community owned. Financing of privately owned facilities is typically by private loan, possibly with some state or federal assistance; large universities also have large endowments and fund-raising activities, a large part of which assist in capital improvement program financing. Public institutions may also be financed by state and local bond issues.

Private institutions have no restrictions on methods of procurement; projects may be negotiated, conventionally bid, use construction management or design-build. Public work must be competitively bid. Typically, contracts are placed for all site and building work, both structural and nonstructural. Equipment and furnishing and their installation are purchased separately from specialized vendors.

Higher education institutions typically emphasize high quality of design and construction and long facility life, though all institutions are also budget conscious. An attractive campus is seen, particularly by institutions which are in a competitive situation, as an important asset.

11.3 PERFORMANCE OF HIGHER EDUCATION FACILITIES (UNIVERSITIES) IN PAST EARTHQUAKES

The most significant experiences of seismic performance of higher education facilities in recent earthquakes has been those related to the Whittier (Los Angeles region) earthquake of 1987, the Loma Prieta (San Francisco Bay region) earthquake of 1989, and the Northridge (Los Angeles) earthquake of 1994. During the Whittier earthquake, a number of buildings at the California State University at Los Angeles suffered some structural damage and extensive nonstructural disruption. One student was killed by a concrete facade panel that fell from a parking structure. During the Loma Prieta earthquake, the Stanford

University campus experienced considerable damage, forcing the closure of a dozen buildings. Subsequently, Stanford convened a special committee to review steps that should be taken to protect the campus against future events. One result was to set up its own seismic safety office with structural engineering staff to determine, in concert with departmental and university representatives, performance objectives for buildings and to review proposed designs. The university played a strong role in the early application of performance-based design strategies for its capital programs.

In the Northridge earthquake, the California State University at Northridge was forced to close for a month and re-open in temporary buildings. Severe damage was done to the welded steel frame of the University Library (Figure 11-1), and buildings on the University of California at Los Angeles (UCLA) campus were slightly damaged. For the most part the serious structural damage to all these campuses was experienced by older reinforced buildings or to unreinforced masonry structures.

The implications of the above-described damage caused a number of universities to become concerned about the ability of their facilities to support continued teaching and research following a more severe event.

Figure 11-1 Fractured 4-inch-thick steel base plate, university building, Northridge, 1994. (photo courtesy of the Earthquake Engineering Research Institute)

In 1997 the University of California at Berkeley committed $1 million to intensify campus planning and developed a 10-point action plan that included a high-level administrative restructuring to focus on campus planning and construction, with extensive focus on seismic safety. The 10-point plan included:

- Creation of a new Chancellor's cabinet-level position of Vice Chancellor to oversee all aspects of the program.
- Determination of the need for full or partial closure of any facilities deemed an unacceptable risk.
- Development of plans for a variety of temporary relocation or "surge" space, sites and buildings.
- Development and initiation of a multi-source financing plan to implement the master plan and implement a seismic retrofit program.
- Conduct of a comprehensive emergency preparedness review, including mitigating nonstructural hazards, assuring that emergency and critical facilities are available, and providing emergency response training.

This plan is now being implemented; a number of key facilities have been retrofitted, and others are in process, with priorities based on a seismic evaluation of all the campus buildings. New buildings are subject to a peer-review process of the proposed seismic design.

11.4 PERFORMANCE EXPECTATIONS AND REQUIREMENTS

The following guidelines are suggested as seismic performance objectives for higher education facilities:

- Students, faculty, staff and visitors within and immediately outside the facilities must be protected at least to a life safety performance level during design-level earthquake ground motions.
- Emergency systems in the facilities should remain operational after the occurrence of design-level earthquake ground motions.
- All occupants should be able to evacuate the school quickly and safely after the occurrence of design-level earthquake ground motions.
- Emergency workers should be able to enter the facility immediately after the occurrence of design-level earthquake ground motions, encountering minimum interference and danger.

11.5 SEISMIC DESIGN ISSUES

The information in this section summarizes the characteristics of higher education facilities, notes their relationship to achieving good seismic performance, and suggests seismic risk management solutions that should be considered.

Seismic Hazard and Site Issues

Unusual site conditions, such as a near-source location, poor soil characteristics, or other seismic hazards, may lead to lower performance than expected by the code design. If any of these other suspected conditions are geologic hazards, a geotechnical engineering consultant should conduct a site-specific study. If defects are encountered, an alternative site should be considered (if possible) or appropriate soil stabilization, foundation and structural design approaches should be employed to reduce consequences of ground motion beyond code design values, or costly damage caused by geologic or other seismic hazards (see Chapter 3 for additional information). If possible, avoid sites that lack redundant access and are vulnerable to bridge or highway closure.

RISK CONSIDERATION

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Structural System Issues

Higher education facilities are of great variety and size, encompassing all types of structure and services. The basic occupancies are teaching, research and administration, but assembly facilities may range from a small rehearsal theater to a multi-thousand seat sports stadium. A large student center may be a cross between a small shopping mall and a community center with retail stores, food service and places of recreation and assembly. As universities become more competitive to attract a wider audience, student-life facilities are tending to become larger and more complex. In addition, many universities provide extensive dormitory facilities.

Teaching requires spaces for small seminar groups, classrooms that are often larger in size than those of a grade school, and large lecture halls with sloped seating and advanced audio-visual equipment. Science teaching requires laboratories and support spaces with services and equipment related to traditional scientific and engineering fields, such as chemistry, biology, physics and computer sciences.

The administration function includes all office functions, including extensive communication services and extensive record keeping. Science research requires laboratories and other special facilities (e.g., greenhouses) that can accommodate a variety of unique spatial, service and utility needs required by researchers; some laboratories such as material sciences, physics, and engineering require heavy equipment with large power demands. Departmental buildings in the humanities may encompass a small administrative function, a variety of teaching facilities, many of them small. Departmental buildings in the sciences may include laboratories and their support space within the same building, and faculty offices may include direct access to research laboratories. Departmental buildings may also include a departmental library. Teaching and research in the biological sciences may include the storage, distribution and use of hazardous substances.

The library is a major campus facility, and a large campus may have several campus-wide libraries. Notwithstanding the rapid advance of computerized information technology and information sources such as the internet, the hard-copy resources of the library continue to be of major importance, and the library is a distinct building type with some specific structural and service demands, such as the ability to safely accommodate heavy dead loads, and to provide a high level of electronic search and cataloging functions.

Because of their functional complexity, large higher education facilities often have complex and irregular architectural/structural configurations. In addition, the spatial variety within many higher education buildings influences some structural choices, and structural design tends to be complex in its detailed layout with a variety of spans and floor-to-floor heights. Some laboratory equipment requires a vibration free environment, which entails special structural and mechanical equipment design. The structural design should focus on reducing configuration irregularities to the greatest extent possible and ensuring direct load paths. Framing systems need careful design to provide the great variety of spatial types necessary without introducing localized irregularities.

DESIGN CONSIDERATION

Since continued operation is a desirable performance objective, structural design of higher education facilities beyond life safety is necessary and design for both structural integrity and drift control need special attention to provide an added level of reliability for the nonstructural components and systems.

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Nonstructural System Issues

As noted above, excessive structural motion and drift may cause damage to ceilings, partitions, light fixtures, and glazing. In addition, storage units, library shelving, and filing cabinets may be hazardous if not braced. Excessive drift and motion may also lead to damage to roof-top equipment, and to localized damage to water systems and fire suppression piping and sprinklers. Heavy laboratory equipment and heavy mechanical and electrical equipment may also be displaced, and be hazards to occupants in close proximity.

Continued operation is particularly dependent on nonstructural components and systems, including purchased scientific equipment, much of which is often of great sensitivity and cost. Many specialized utilities must be provided, some of which involve the storage of hazardous substances. These must be protected against spillage during an earthquake. Distribution systems for hazardous gases must be well supported and braced. Water must be provided to many spaces, and thus the likelihood of water damage is greater. Cosmetic wall and ceiling damage that can easily be cleaned up in an office building may shut down a research laboratory.

RISK CONSIDERATION

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The responsibilities within the design team for nonstructural component support and bracing design should be explicit and clear. The checklist for responsibility of nonstructural design in Chapter 12 (see Figure 12-5) provides a guide to establishing responsibilities for the design, installation, review and observation of all nonstructural components and systems.