DESIGN AND PERFORMANCE ISSUES RELATING TO HEALTHCARE FACILITIES 9

9.1 INTRODUCTION

Healthcare facilities are the places where America goes for treatment for most of its healthcare and are the places that need to be available to them after being injured in an earthquake. Regional or local hospitals, outpatient clinics, long-term care facilities are all examples of healthcare facilities that serve in this role. As healthcare companies 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 healthcare facilities that should be kept in mind during the design and construction phase of new facilities:

- Protection of patients and healthcare staff is a very high priority.
- Healthcare occupancy is a 24 hour/7 day-per-week function.
- Acute-care hospitals have a large patient population that is immobile and helpless, for whom a safe environment is essential. This particularly requires a safe structure and prevention of falling objects.

- Hospitals are critical for emergency treatment of earthquake victims and recovery efforts.
- Medical staff has a crucial role to play in the immediate emergency and during the recovery period.
- Ensuring the survival of all equipment and supplies used for emergency diagnosis and treatment is essential for patient care.
- Ensuring the survival of medical and other records, whether in electronic or written form, is essential for continued patient care.
- Closure of hospitals for any length of time represents a very serious community problem exacerbated by the possibility of the loss of healthcare personnel who are in high demand or unable to work because of personal earthquake-related consequences (e.g., their own injury).
- Many hospitals are not only service providers but also profit or non-profit businesses and, since their operating costs and revenues are high, every day that the facility is out of operation represents serious financial loss.

9.2 OWNERSHIP, FINANCING, AND PROCUREMENT

Healthcare facilities are typically developed by a private non-profit or for-profit hospital corporation or an HMO (health maintenance organization). Many are also developed by a local, state or federal government agency. Financing of privately owned facilities is typically by private loan, possibly with some state or federal assistance; for-profit hospitals may issue stock when access to capital is required, and hospitals also conduct fund-raising activities, a large part of which assist in capital improvement program financing. State and local public institutions are financed by state and local bond issues. Non-profit hospitals sometime issue bonds to the public.

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 (structural and nonstructural). Medical equipment and furnishings and their installation are purchased separately from specialized vendors.

Hospitals typically emphasize high quality of design and construction and long facility life, though all institutions are also budgeting conscious. An attractive and well equipped hospital site and building campus are seen as an important asset, particularly by private institutions that are in a competitive situation.

9.3 PERFORMANCE OF HEALTHCARE FACILITIES IN PAST EARTHQUAKES

The most significant experience of seismic performance of healthcare facilities in recent earthquakes was that of the Northridge (Los Angeles), California, earthquake of 1994. The San Fernando, California, earthquake of 1971 seriously damaged several medical facilities, including the then brand-new Los Angeles County Olive View Hospital. Most of the fatalities in this earthquake occurred in hospitals, principally the result of the collapse of an older unreinforced masonry Veterans Hospital building. In response to the recognized need for superior seismic performance by hospitals, the California Legislature enacted the Alfred E. Alquist Hospital Facilities Seismic Safety Act, which became effective in 1973. This Act mandated enhanced levels of design and construction. The Act proved very effective in limiting structural damage in the Northridge earthquake; no post–Act hospitals were red-tagged (posted with a red UNSAFE postearthquake safety inspection placard) and only one was yellow-tagged (posted with a yellow RESTRICTED USE placard). However, nonstructural damage was extensive, resulting in the temporary closure of several of the post-1973 buildings and the evacuation of patients.

Long-term closure only occurred in hospitals affected by the 1994 Northridge earthquake when there was structural damage; this only affected some pre-1973 hospitals. While structural damage can cause severe financial losses, the more important loss of ability to serve the community during the hours following the earthquake is more likely to be caused by nonstructural damage. At Holy Cross Medical Center, for example, damage to the air handling system and water damage from broken sprinklers and other piping required evacuation, but most services were restored within a week and paramedic units opened within 3 weeks (Figure 9-1). At Olive View Hospital (the replacement for the hospital damaged in the 1971 San Fernando earthquake) the structure was virtually undamaged (Figure 9-2), even though it was subject to horizontal ground accelerations approaching 1 g (g = acceleration of gravity). Broken piping and leakage, however, caused the evacuation of all patients and closure for one week.

During the 1994 Northridge earthquake, most nonstructural damage in healthcare facilities occurred to water related components. Damage

Figure 9-1 Exterior view of Holy Cross Medical Center, which was evacuated after the 1994 Northridge earthquake due to damage to the HVAC system. (photo courtesy of the Earthquake Engineering Research Institute)

Figure 9-2 Aerial view of Olive View Hospital, which sustained no structural damage during the 1994 Northridge earthquake, but was closed for a short while after the earthquake because of water leakage from broken sprinklers and waterlines. (photo courtesy of the Earthquake Engineering Research Institute)

was caused by leakage from sprinklers and domestic water and chilled water lines; water shortages were caused by lack of sufficient on-site storage. Twenty-one buildings at healthcare facilities suffered broken non-sprinkler water lines with most of the damage in small lines, less than 2-1/2 inches in diameter, for which bracing was not required by code. Sprinkler line breakage occurred at 35 buildings, all of which was caused by small unbraced branch lines.

Following the 1994 Northridge earthquake, a new state law was passed that required all hospitals that are deemed at "significant risk of collapse" to be rebuilt, retrofitted or closed by 2008, and all acute care hospitals to meet stringent safety codes by 2030. All hospital plans are to be reviewed by the Office of Statewide Health Planning and Development (OSHPD). The 1972 and 1994 hospital legislation is similar in scope to the 1933 and 1976 Field legislation enacted to protect schools, which is generally regarded to have been very successful in achieving its objectives of providing earthquake-safe schools.

9.4 PERFORMANCE EXPECTATIONS AND REQUIREMENTS

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

- Patients, staff and visitors within and immediately outside healthcare facilities must be protected at least to a life-safety performance level during design-level earthquake ground motions.
- Safe spaces in the facility (which, depending on climatic conditions, may be outside) should be available for emergency care and triage activities within two hours of the occurrence of design-level earthquake ground motions.
- Most hospital services should be available within three hours of the occurrence of design-level earthquake ground motions.
- Emergency systems in the facility should remain operational after the occurrence of design-level earthquake ground motions.
- The facility services and utilities should be self-sufficient for four days after the occurrence of design-level earthquake ground motions.
- Patients and staff should be able to evacuate the building quickly and safely after the occurrence of design-level earthquake ground motions.

- Emergency workers should be able to enter the building immediately after the occurrence of design-level earthquake ground motions, encountering minimum interference and danger.
- There should be no release of hazardous substances as a result of the occurrence of design-level earthquake ground motions.

9.5 SEISMIC DESIGN ISSUES

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

Seismic Hazard and Site Issues

RISK CONSIDERATION

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.

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.

Structural System Issues

Healthcare facilities are of great variety and size, encompassing all types of structure and services. Large hospitals accommodate several occupancy types. Acute care is a highly serviced short-term residential occupancy, and many diagnostic, laboratory and treatment areas require high-tech facilities and services. Service areas such as laundry, food service receiving, storage and distribution are akin to industrial functions, and administration includes typical office, communication and record-keeping functions.

Smaller healthcare facilities may encompass one or more functions such as predominantly longer residential care, or specialized treatment such as physical rehabilitation or dialysis. This functional variety influences some structural choices but the structure, as in all buildings, plays a background role in providing a safe and secure support for the facility activities. Since continued operation is a desirable performance objective, structural design 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.

DESIGN CONSIDERATION

Since continued operation is a desirable performance objective for healthcare facilities, structural design 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.

The heavy and complex service demands of hospitals require greater floor-to-floor heights than for other buildings (such as offices) to provide more space above a suspended ceiling to accommodate the services. A number of hospitals have been designed with "interstitial" service space—a complete floor inserted above each functional floor to accommodate the services and make their initial installation and future change easier to accomplish (see Figure 9-3).

Because of their functional complexity, hospitals often have complex and irregular configurations. Broadly speaking, smaller hospitals are planned as horizontal layouts; large hospitals often have a vertical tower for the patient rooms elevated above horizontally planned floors for the diagnostic, treatment and administrative services. Emergency services are generally planned at the ground floor level with direct access for emergency vehicles. 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.

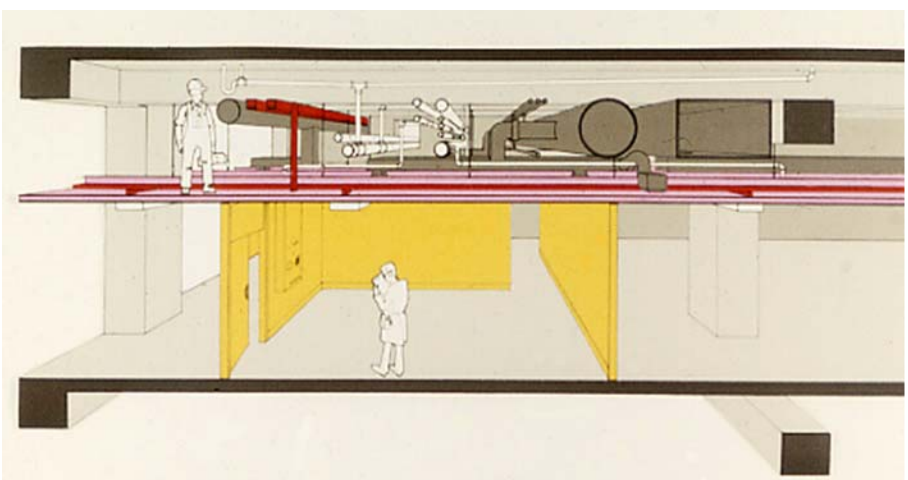

Figure 9-3 Sketch showing typical interstitial space for nonstructural components and systems in new hospitals.

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 localized damage to water systems and fire suppression piping and sprinklers. Heavy equipment such as shop machinery, kilns 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 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, such as pharmaceuticals and oxygen in tanks. 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, unlike an office building, where the provision is much more limited, and thus the likelihood of water damage in healthcare facilities is greater.

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.