

California's
HOSPITAL
Seismic Safety Law

**Its History,
Implementation,
& Progress**



2005

California's **HOSPITAL** **Seismic Safety Law**

Arnold Schwarzenegger, Governor
State of California

S. Kimberly Belshé, Secretary
California Health & Human Services Agency

David M. Carlisle, M.D., Ph.D., Director
Office of Statewide Health Planning & Development

Kurt Schaefer, P.E., Deputy Director
Facilities Development Division

**Its History,
Implementation,
& Progress**

California's Hospital Seismic Safety Law Its History, Implementation and Related Issues

Table of Contents

California's Earthquake History.....	1
When Will the Next One Hit?	6
How Have Californians Responded?	8
Why Hospitals and Not Other Kinds of Structures?	10
How Vulnerable are California's Hospitals?	11
What is OSHPD Doing to Help Hospitals Comply?	13
What is the Status of Hospital Compliance?	14
How Much is this Entire Program Going to Cost?	15
Are Strengthened Hospitals Resistant to More than Just Earthquakes?	17
Where Do We Go From Here?	18

California's Earthquake History

California has experienced major, catastrophic earthquakes in the past and will certainly experience more in the future. These quakes occurred throughout the state, NOT just in the more commonly perceived “earthquake zones” of Los Angeles and the Bay Area.

- Geologic and archaeological evidence shows a long history of major earthquakes up and down the state as well as eastward to the Sierra. Little of the state is considered “earthquake free”, and the majority of the state lies within active seismic zones.
- Earthquakes worldwide have killed millions, injured and left homeless tens of thousands, and caused inestimable economic losses. History has recorded more than 3,400 deaths¹ attributable to California's earthquakes during the last century.
- Historical records reveal that California has experienced—on average—a moderately strong earthquake (M6.0² to M6.9) every two to three years.
- Members of the 1769 Gaspar de Portola expedition wrote of the earth shaking, a phenomenon that occurs to this day.
- 1857 – The M7.9 Fort Tejon quake, California's strongest earthquake, was felt from San Francisco to Los Angeles. The shaking lasted from one to three minutes and caused extensive displacement along the San Andreas Fault. One person died.

¹ United States Geological Survey Web site neic.usgs.gov/neis/eqlists/us_deaths.html

² M represents the magnitude of the quake as measured by the Richter scale. A quake is considered major from M6 to M6.9, and catastrophic from M7 to M7.9.

- 1868 – A quake on the Hayward Fault, the principle active branch of the San Andreas in central California, killed 30 people and destroyed numerous buildings in the Bay Area. It was referred to as “the great earthquake” until the San Francisco 1906 temblor.
- 1872 – The M8.2 Owens Valley quake occurred on the Nevada Fault and killed 27 Californians in Lone Pine. It destroyed 52 of the community’s 59 adobe houses and was felt 200 miles away near Ventura.
- 1892 – Vacaville lost most of its brick buildings and many wood structures in a M6.6 quake. The temblor produced ground fissures in Winters and Dixon.
- 1899 – A strong quake on the San Jacinto Fault killed six people and left most of the brick buildings in San Jacinto and Hemet in ruins, with only two chimneys remaining upright.
- 1906 – The M7.8 San Francisco quake killed thousands (earthquake and resulting fires), injured thousands more and sparked raging fires that leveled much of the city. Damage was estimated at over \$500 million (\$9.8 billion³). Ground displacement can be seen to this day on many sections of the San Andreas Fault. Ground shaking was perceptible from Coos Bay, Oregon, to Los Angeles and covered an area of 347,000 square miles.
- 1915 – Two destructive quakes (M6.2) an hour apart caused extensive damage in the Imperial Valley, and killed six and injured others just across the Mexican border at Mexicali.
- 1918 – Another San Jacinto Fault shock (M6.8) leveled all but one new concrete structure and one frame building in San Jacinto’s business section.

³ Damage figures in parentheses have been recalculated to reflect current dollar values. The revised damage estimates do NOT reflect anticipated losses if a quake of similar magnitude occurred today in that locale.

- 1925 – A M6.3 shock on the Mesa Fault in the Santa Barbara Channel killed 13 and caused \$8 million (\$88 million) in damages. Few buildings escaped damage. One building on marshy ground withstood the shaking, but its foundation sank 19 feet.
- 1933 – The devastating M6.4 Long Beach earthquake killed 115 and caused \$40 million (\$595 million) in damage. Damage was exacerbated by poor structural work and buildings constructed on landfill. Buildings collapsed, water tanks fell through roofs and houses shifted on their foundations. Many schools were severely damaged, leading to California's landmark legislation requiring schools be constructed to strict earthquake standards.
- 1940 – The M7.1 Imperial Valley quake killed nine people and damaged 80 percent of the buildings in Brawley. Half of the town's structures had to be condemned. In the first strong test of public schools designed to be earthquake-resistant, 15 experienced no damage.
- 1952 – A catastrophic M7.3 quake in Kern County killed 12 Californians, injured many more, and caused \$60 million (\$435 million) in property damage. Well-designed structures withstood the temblor but many older buildings collapsed. The temblor and one major aftershock (M 5.8) killed two and caused extensive damage to many buildings already weakened by the first quake. The quake occurred on the lesser-known White Wolf Fault.
- 1964 – A M7.9 quake in Alaska destroyed major sections of Anchorage. The quake triggered a tsunami that struck much of the California coastline and killed 11 people in Crescent City. Estimated losses along the California coast ranged from \$1.5 to \$2.375 million.

- 1971 – The M6.5 Sylmar earthquake in the San Fernando Valley hit before rush hour, killing 65 people. Most fatalities occurred in the Veterans Hospital. Another 2,000 people suffered serious injuries. Damage exceeded half a billion dollars (over \$2.4 billion). Failures were traced to poor building codes, errors in design, and construction defects.
- 1983 – Coalinga Earthquake. The M6.7 quake occurred on a previously unknown fault and caused major damage. While there were injuries, no lives were lost.
- 1989 – The Loma Prieta (M6.9) quake struck just as the World Series was beginning in San Francisco. Centered 50 miles south in the Santa Cruz Mountains, the temblor killed 63, collapsed an elevated portion of a freeway in Oakland and a portion of the Bay Bridge, sparked fires that burned much of San Francisco's Marina district, leveled portions of Santa Cruz and Watsonville, and disrupted transportation and services for months. It left behind more than \$6 billion in damages (over \$9.5 billion).
- 1992 – The M7.2 Cape Mendocino quake gave Humboldt County residents a reminder of the Cascadia subduction zone offshore from Petrolia. The main temblor and a M6.6 aftershock the next day injured more than 350 people. Scientists predict that a larger quake in that zone could trigger a tsunami.
- 1994 – The M6.7 Northridge quake centered in the San Fernando Valley killed 57 Californians, injured more than 9,000 and threw much of the Los Angeles basin into turmoil as roads were made impassable and freeways collapsed. Two hospitals suffered major structural damage, although no lives were lost in the hospitals. The quake and its many aftershocks left behind more than \$40 billion in damage (\$52 billion).

- Maps from the US and California Geological surveys show that some areas have been relatively quiet seismically in the last 90 years but were active in the previous 100 years. These relatively quiet areas include the San Andreas system faults, which include the San Jacinto and Hayward-Rodgers Creek faults and parts of the Sacramento Valley. A M6.6 quake in April, 1892, struck the town of Vacaville, leaving one person dead and more than \$225,000 in damages.⁴

⁴ California Geological Survey, www.consrv.ca.gov/cgs/rghm/quakes/eq_chron.htm.

When and Where Will the Next One Hit and How Much Might It Cost in Damages?

It is not a question of whether another major earthquake will strike California; rather it is a question of WHEN and WHERE the next temblor will hit.

- A moderately strong earthquake (M6.0 to M6.9) occurs in California every two to three years.⁵
- Scientists believe there is a 62 percent probability of at least one magnitude 6.7 or greater quake striking the San Francisco Bay region before 2032. Southern California faces a 60 percent probability of a major quake during the same period.
- Scientists predict that somewhere in Southern California (not everywhere—many residents would not be affected) should experience a M7.0 or greater earthquake about seven times each century. About half of these quakes will be on the San Andreas "system" (the San Andreas, San Jacinto, Imperial, and Elsinore Faults) and half will be on other faults. The equivalent probability in the next 30 years is 85 percent.⁶
- Residents in coastal areas of San Mateo, Santa Cruz and Monterey counties, sandwiched between the San Andreas and San Gregorio faults, face a combined 34 percent chance of a magnitude 6.7 or greater quake before 2032.
- Since the great San Francisco earthquake of 1906, no major quake has been centered near a densely populated part of the Bay Area. The 1989 magnitude 6.9 Loma Prieta, which killed more than 40 people in the region's urban core, was centered 50 miles away in a lightly populated area.

⁵ California Geological Survey, Note 31.

⁶ Southern California Earthquake Center (SCEC) www.data.scec.org/general/PhaseII.html.

- The population for the SF Bay Area is projected to exceed 8.2 million by 2025, with most of this growth in Solano, Napa and Sonoma counties (30 percent) and Contra Costa, Alameda, and Santa Clara counties (15-20 percent).
- **A repeat of the 1906 earthquake** would rupture four segments of the San Andreas Fault and would cause approximately **\$54 billion economic loss** due to building damage.⁷
- In **Southern California**, the most damaging potential quake would be a M7.1 event on the Puente Hills fault, with **estimated losses of \$69 billion**. A M6.9 on the Newport-Inglewood fault would result in about \$49 billion expected loss.⁸
- A California Department of Conservation study estimates that the **average annual loss** from earthquake damage to **buildings only** over the next several decades will be \$2.2 billion in today's dollars. When associated losses to contents, inventory and income are added, the expected annual loss in California increases to about \$4.7 billion. That total does not reflect the cost associated with injuries to occupants or other economic losses.⁹
- Based on the above estimates, in the next ten years California can expect to incur almost \$40 billion in damages to structures and another \$8 billion in other losses. Again, these figures do not include the costs associated with injuries to occupants or other economic losses.
- The same study estimated annual economic loss due to building damage for the state at \$2.2 billion. The areas of highest expected annual loss are the Los Angeles area and the San Francisco Bay Area.¹⁰

⁷ California Geological Survey, Earthquake Loss Estimation, by B. Rowshandel, M. Reichle, C. Willis, T. Cao, M. Petersen, and J. Davis.

⁸ Ibid.

⁹ Ibid.

¹⁰ Ibid.

How Have Californians Responded?

Californians have historically responded to major earthquakes and resultant loss of life by requiring stricter building codes to protect lives and property, with special requirements for critical buildings that need extra protection. Today, California is the world leader in earthquake-resistant design.

- 1933 – The Long Beach earthquake (M6.3, 5:55 p.m.), killed 115 people, destroyed 70 schools and left another 120 schools badly damaged. School was not in session when the quake struck; had it occurred a few hours earlier, many students would have died.
- Less than one month later the California Legislature passed the Field Act requiring public schools and other public buildings to be substantially earthquake resistant.
- Since passage of the law, no Field Act school has collapsed in an earthquake.
- In 1973, as a direct result of the devastation caused by the 1971 Sylmar quake (65 deaths and a hospital collapse), the Legislature passed the Alfred E. Alquist Hospital Seismic Safety Act. The act requires that acute care hospitals be designed and constructed to withstand a major earthquake and remain operational immediately after the quake.
- After the 1994 Northridge earthquake, in which many older (pre-1973) hospital buildings performed poorly and sustained considerable damage, the Legislature amended the Alquist Act to strengthen seismic requirements for hospitals.
- SB 1953 amended the Alquist Act to require hospitals to evaluate and rate all their general acute care hospital buildings for seismic resistance. They employed standards developed by the California Office of Statewide Health Planning and Development to measure a building's ability to withstand a major earthquake.

- By 2001, hospitals reported the findings of their evaluation. They showed that approximately 40 percent of California's hospital buildings are at risk of collapse in a major earthquake.
- Compliance plans that hospitals submitted to OSHPD by January 1, 2002, indicated the facilities' intent to do one of the following:
 - Retrofit the buildings for continued acute care operation beyond 2030.
 - Partially retrofit the building for initial compliance with closure or replacement by 2002, 2008 or 2030.
 - Relocate acute care services or close or demolish the building. Hospitals may request an extension of the 2008 deadline to 2013.

Why Hospitals and Not Other Kinds of Structures?

Hospitals must remain standing and functional during and after an earthquake for the safety of patients and staff AND to provide medical assistance to earthquake victims.

During and immediately after a disaster, hospital buildings are the beacon of life and hope for a community.

- Hospitals occupy a unique place in society's survival capability. Following a catastrophic event such as a major earthquake or other natural disaster, or in the event of a terrorist attack or serious accident, the public turns to its hospitals for emergency care. If these critical buildings have been damaged so that they cannot function, then society remains all the more vulnerable.
- Without functioning hospitals, it takes much longer for a community to recover from an earthquake. This prolonged recovery seriously retards the area's economic and social renewal.
- Because the evacuation of seriously ill patients can be detrimental and sometimes fatal, hospitals cannot be evacuated like other buildings, making it imperative that they survive earthquakes intact.
- Replacing a heavily damaged hospital building can take a decade. Eleven years after the 1994 Northridge earthquake, some damaged hospital buildings are still closed and replacement of heavily damaged hospital buildings in Los Angeles is not yet complete, depriving the community of sorely-needed healthcare resources.
- From a strictly practical standpoint, it is important to protect the investment of taxpayer dollars in many hospitals rebuilt with public money. For example, the Federal Emergency Management Agency (FEMA) paid over \$3 billion to repair hospital damage caused by the 1994 Northridge earthquake.

How Vulnerable are California's Hospitals?

Following passage of SB 1953, the state's 442 acute care hospitals evaluated their buildings for structural and non-structural vulnerabilities.¹¹ They reported to OSHPD that a significant number of their buildings are at risk for collapse in the event of a major earthquake.

The evaluations, completed by January 1, 2001, found that:

- At the time the hospitals evaluated their buildings, **973 (37%) of the state's hospital buildings posed a significant risk of collapse and a danger to the public (SPC1).**¹² They must be retrofitted, replaced or removed from acute care services by January 1, 2008. Some hospitals may delay compliance until 2013 under certain circumstances and with OSHPD's approval.
- Hospitals determined that **175** buildings do not significantly jeopardize life but may not be repairable or functional following a strong quake **(SPC 2).** These buildings must be brought into compliance with the Alquist Act by January 1, 2030 or be removed from acute care service.¹³

¹¹ It is important to note that many hospitals are comprised of multiple buildings, some of which may comply with seismic requirements while others may be older and out of compliance.

¹² Structural Performance Category 1 (SPC-1) - These buildings pose a significant risk of collapse and a danger to the public after a strong earthquake. These buildings must be retrofitted, replaced or removed from acute care service by January 1, 2008.

¹³ SPC-2 - These buildings are in compliance with pre-1973 California Building Code or other applicable standards, but are not in compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act. They do not significantly jeopardize life but may not be repairable or functional following strong ground motion. These buildings must be brought into compliance with the Alquist Act by January 1, 2030 or be removed from acute care service.

- There are more than 1,400 hospital buildings in the three remaining structural performance categories (SPC-3, SPC-4 and SPC-5).¹⁴ They are considered capable of providing services following a strong quake and may be used without restriction to 2030 and beyond.

¹⁴ SPC-3 - These buildings are in compliance with the structural provisions of the Alquist Act. In a strong earthquake, they may experience structural damage that does not significantly jeopardize life but may not be repairable or functional following strong ground motion. These buildings will have been constructed or reconstructed under a building permit obtained through OSHPD. They can be used to 2030 and beyond.

SPC-4 - These buildings are in compliance with the Alquist Act but may experience structural damage which could inhibit the building's availability following a strong earthquake. These buildings will have been constructed or reconstructed under a building permit obtained through OSHPD. They may be used to 2030 and beyond.

SPC-5 - These buildings are in compliance with the structural provisions of the Alquist Act and are reasonably capable of providing services to the public following strong ground motion.

What is OSHPD Doing to Help Hospitals Comply?

To help hospitals comply with SB 1953, passed in 1994 after the Northridge quake, OSHPD has developed an expedited and intense program to review and approve hospital retrofit and building plans as part of the ongoing, phased process to ensure that all hospital buildings comply with the law.

- OSHPD has worked vigorously to assist hospitals and their design teams as they submit plans for earthquake retrofit or rebuilding.
- OSHPD has hired additional engineers and architects to review and approve hospital construction plans.
- Most seismic evaluations and plans submitted to OSHPD have been reviewed and most have been approved or returned to the hospital design teams for further work.
- Of the more than 750 projects currently under submission to OSHPD, 29 percent are under review at OSHPD while 71 percent have been returned to the design consultants for corrections. OSHPD cannot go any further in approving building projects until the corrected plans are resubmitted and found compliant with the law and the applicable hospital building regulations.
- Although OSHPD may cancel projects not resubmitted within six months, OSHPD has not exercised that option in the past.¹⁵

¹⁵ That policy is about to change. The Hospital Building Safety Board recently recommended that OSHPD notify all design consultants that plans not resubmitted by the six-month deadline will be considered cancelled. Letters will be sent after projects have remained with designer teams 150 days.

What is the Status of Hospital Compliance?

Progress is being made to bring California's hospitals into compliance with recognized seismic building codes. It is not unrealistic to imagine a day when Californians can count on their hospitals surviving a catastrophic earthquake.

To date:

- There is currently \$10 billion in hospital planning and construction underway in California.
- OSHPD has 1,693 projects (major and minor) under review—projects valued at \$4.4 billion. OSHPD is observing another 2,651 projects valued at \$4.6 billion, which have received plan approval and are under construction. Every project submitted is designed to comply with seismic safety codes and with all of California's relevant building codes.
- Since enactment of SB 1953, 53 hospitals have constructed new or replacement buildings. While the new buildings obviously meet the law's current requirements, older buildings on the same hospital campus may not yet comply.

How Much is this Entire Program Going to Cost?

California's seismic requirement for hospitals has been a catalyst for change.

- It has forced hospitals to look closely at their structures in light of the latest medical technology and patients' demands for the best care possible.
- Training, technology, equipment, diagnostics and pharmacology have all advanced exponentially in the past 60 years, making older hospitals dramatically inefficient and unable to provide the latest in medical science.
- Construction costs attributable to seismic mandates may also include non-seismic issues such as hospital modernization, new technology, patient-driven demands for upgraded facilities, and general building material and labor costs.
- A recent survey showed that healthcare-related construction continues to boom. Rising costs haven't dampened this nationwide building activity, especially in California where seismic mandates are encouraging the "strongest healthcare construction market in the country."¹⁶
- Construction costs are on the rise. Cost increases in construction projects can be traced to:
 - Rising cost of structural steel and concrete
 - Escalating labor expenses
 - Soaring oil prices
 - Adequate work for contractors, reducing the number bidding on projects
- A RAND Corporation report in 2002 found that as little as \$3 billion of estimated hospital construction costs was attributable to actual seismic retrofit costs. The remaining costs

¹⁶ Modern Healthcare Magazine, March 2005.

involve replacing an aged infrastructure dating back to the early post-World War II era, a major factor in the cost of day-to-day operations. It is expensive to run these older hospitals due to the inefficient physical plant designed for providing 20th century healthcare in the 21st century.

- Some hospitals are moving ahead with major construction for a variety of reasons. These include:
 - Outmoded hospital design
 - Bigger emergency departments
 - Improved and enhanced care spaces for technology such as MRI, dialysis, and organ transplant
 - More patient-friendly healthcare facilities such as private rooms, and meditation and healing gardens
 - An aging and demanding population
 - Change in hospitalization such as greater use of out-patient facilities and Intensive Care units
- The state's seismic requirement does not seem to be an impediment when a hospital is serious about its future.

Are Strengthened Hospitals Resistant to More than Just Earthquakes?

Hospitals designed to withstand major earthquakes will also be more likely to remain standing following a terrorist attack, so any retrofits and rebuilding to comply with seismic safety laws serve a dual purpose.

- Recent engineering studies have concluded that buildings constructed to withstand a major earthquake would most likely be more resistant to explosions and other types of destruction.
- The Federal Emergency Management Agency (FEMA) reviewed damage to the Murrah Building in Oklahoma City, destroyed by a terrorist bomb in 1995, and concluded that certain construction systems used to make buildings earthquake resistant may well make them resistant to damage from blast. The report recommended, ***“These structural systems be considered where there is a significant risk of seismic and/or blast damage.”***
- A report issued by the Multidisciplinary Center for Earthquake Engineering Research (MCEER) studied the collapse of the World Trade Center on 9/11/2001 to see if parallels could be drawn between the terrorist attack and the impact of a catastrophic earthquake. The report states, “The attack and its aftermath (let us explore) a variety of engineering and emergency management issues.”
- Buildings designed to resist earthquakes are inherently “tough.” Older hospitals are more vulnerable to damage from all manmade and natural disasters.
- Possible additional funding for anti-terrorist construction may be available to hospitals.

Where Do We Go From Here?

The Longer You Wait, the More It Costs and the Greater the Potential for a Large Earthquake or other Disaster.

The current hospital seismic laws were written to accommodate some hospitals' concerns about costs, and many have chosen an option to delay work when possible. This allows them to incorporate seismic features into anticipated remodeling and updating of their facilities in the future.

- The average age of the riskiest hospitals is nearly 50 years—and the average useful life of a hospital building is estimated to be 40 to 50 years. Often it makes better sense to replace rather than strengthen the building.
- In 2008, the average age of affected hospital buildings will be between 45-49 years.
- While the need to modernize a facility is often the primary reason for replacing a building, seismic concerns may act as a catalyst.
- Upgrading hospital buildings not only improves seismic safety, it benefits the hospital as well. These upgraded facilities may also achieve the following:
 - Experience far fewer losses in the event of a terrorist attack, earthquake or other disaster.
 - Provide the opportunity to build a new, efficient physical plant to accommodate the healthcare needs of today and the future.



Equitable Healthcare Accessibility for California
Office of Statewide Health Planning & Development