The Northridge Earthquake - 30 Years Later

A Catalyst for Engineering Resilient Communities

Webinar Series

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2

The Northridge Earthquake - 30 Years Later

A Catalyst for Engineering Resilient Communities

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- American Society of Civil Engineers (ASCE) Infrastructure Resilience Division
- ASCE Los Angeles Section
- Earthquake Engineering Research Institute (EERI) Southern California Chapter
- Structural Engineers Association of Southern California (SEOASC)
- Earthquake Country Alliance (ECA), led by the Statewide California Earthquake Center

3

NORTHRIDGE 30
1994 2024

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Episode 1: The January 17, 1994 Northridge Earthquake – Science & Engineering Aspects
K. Hudnut, J. Stewart, C. Davis, D. Cocke
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Episode 2: Insurance Issues and Impacts Following the Northridge Earthquake
C. Scawthorn, J. Maffei
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4

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Episode 3: 30 Years of Progress in Quantification of Seismic Hazards
Y. Bozorgnia
EarthquakeCountry.org/northridge30-webinar3

Episode 4: An Unexpected Milestone in Real-Time Loss Estimation
R. Eguchi, D. Wald
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5

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Episode 5: Legacies of the Northridge Earthquake in Disaster Recovery Planning and Policy

Laurie Johnson, Principal, Laurie Johnson Consulting | Research

Rob Olshansky, Prof. Emeritus, Univ. of Illinois at Urbana-Champaign

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6

The Northridge Earthquake - 30 Years Later

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Episode 6: The Northridge Earthquake – the Catalyst for Resilience of Healthcare in California

Marshall Lew, Ph.D., G.E.

Geotechnical Consultant

Former Member of the California Hospital Building Safety Board(1999-2006 and 2015-2023)

7

California is no stranger to earthquakes.

M 7.9 – The Great 1906 San Francisco Earthquake

St. Mary's Hospital San Francisco

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M 6.8 - The 1925 Santa Barbara, California Earthquake

St. Francis Hospital Santa Barbara

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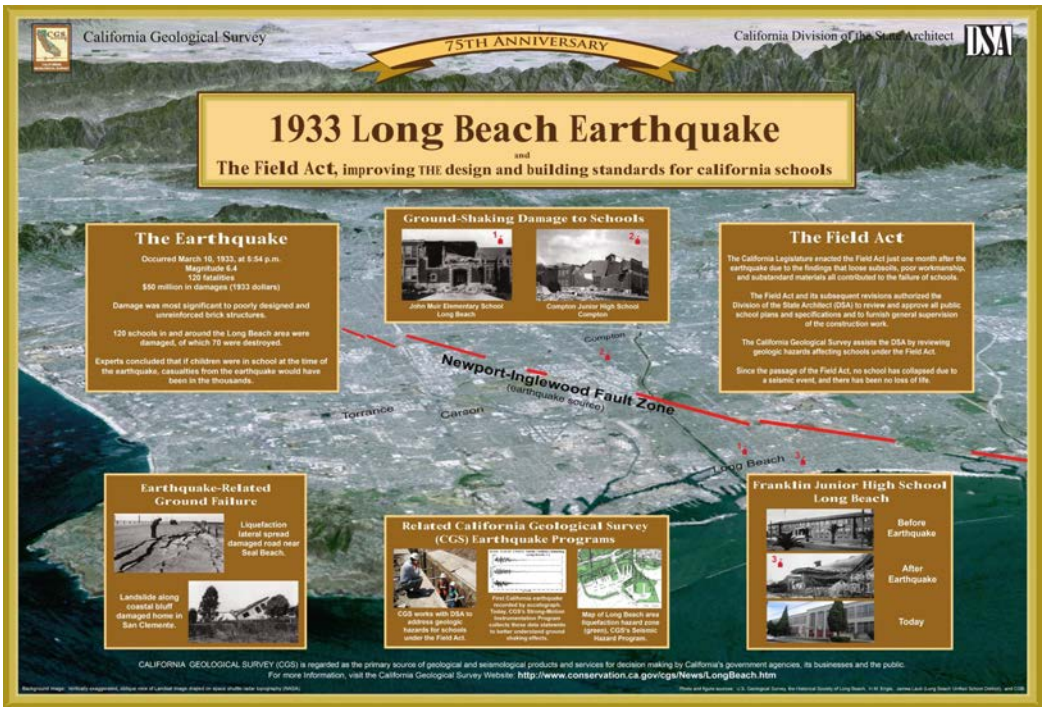
M 6.4 - The 1933 Long Beach, California Earthquake

Seaside Hospital, Long Beach



The Field Act did not apply to hospitals, only to public schools

M 6.6 – 1971 San Fernando Earthquake

San Fernando Veterans Administration Hospital complex. Four buildings collapsed resulting in 47 deaths.

12

M 6.6 – 1971 San Fernando Earthquake

Olive View Medical Center, Sylmar

Hospital had been opened one month earlier

13

12 years after the San Fernando Earthquake, the Alfred E. Alquist Hospital Facilities Seismic Safety Act of 1983 was passed by the State Legislature and signed by the Governor – OSHPD was born.

(a) It is the intent of the Legislature that hospital buildings that house patients who have less than the capacity of normally healthy persons to protect themselves, and that must be reasonably capable of providing services to the public after a disaster, shall be designed and constructed to resist, insofar as practical, the forces generated by earthquakes, gravity, and winds. In order to accomplish this purpose, the department shall propose proper building standards for earthquake resistance based upon current knowledge and provide an independent review of the design and construction of hospital buildings.

(b) Local jurisdictions are preempted from the enforcement of all building standards published in the California Building Standards Code relating to the regulation of hospital buildings and the enforcement of other regulations adopted pursuant to this chapter, and all other applicable state laws, including plan checking and inspection of the design and details of the architectural, structural, mechanical, plumbing, electrical, and fire and panic safety systems, and the observation of construction. The department shall assume these responsibilities.

Hospital disaster operations during the 1989 M6.9 Loma Prieta earthquake

Objective: To study hospital disaster operations following a major United States disaster.
Design: Researchers interviewed all 51 hospital administrators and 49 of 51 emergency department (ED) charge nurses and emergency physicians who were on duty at the study hospitals during the 13-hour period immediately following the 1989 Loma Prieta earthquake.
Setting: The 51 acute-care hospitals in the six northern California counties most affected by the Loma Prieta earthquake.
Measurements: Questionnaires and in-person interviews.
Results: The most frequently noted problem was lack of communications within and among organizations. Hospitals received inadequate information about the disaster from local governmental agencies. Forty-three percent of hospitals had inadequate back-up power configurations, and five hospitals sustained total back-up generator failures. Twenty hospitals performed partial evacuations.
Conclusions: The Loma Prieta earthquake did not cause total disruption of hospital services. Hospitals need to work with local governmental agencies and internal hospital departments to improve disaster communications.

Martchenke J, Pointer JE. Hospital disaster operations during the 1989 Loma Prieta earthquake. Prehosp Disaster Med. 1994 Jul-Sep;9(3):146-53. doi: 10.1017/s1049023x0004125x. PMID: 10155521.

M 6.7 - The 1994 Northridge Earthquake

Kaiser Permanente Medical Office Building Granada Hills

Example of non-ductile concrete frame building

16

16

M 6.7 - The 1994 Northridge Earthquake

Sylmar County Hospital (Olive View) – Replacement hospital with steel shear walls

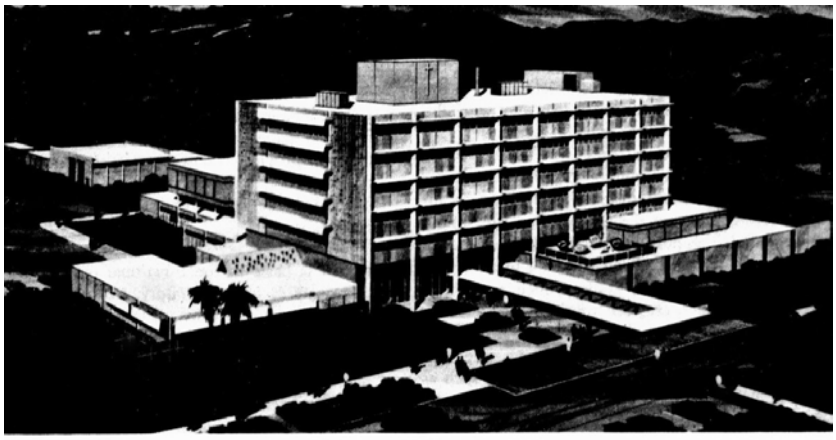
17

17

M 6.7 - The 1994 Northridge Earthquake

Holy Cross Hospital Mission Hills

A welded steel moment-resisting frame building



HOLY CROSS HOSPITAL

Engineers inspecting Holy Cross Medical Center have discovered 35 cracks in steel support beams, but hospital officials say most of the breaks are minor and pose no immediate danger to patients or staffers.
Holy Cross began inspecting the beams on its own initiative after widespread discussion of cracks in steel-frame buildings caused by the Northridge earthquake, said Allene Nungesser, the hospital's executive vice president and chief operating officer.
Using an ultrasound device, engineers have examined more than half of the 400 joints in the building's steel frame, she said. (Source: Los Angeles Times)

USC University Hospital – first base isolated hospital in the world. Opened around 1990.

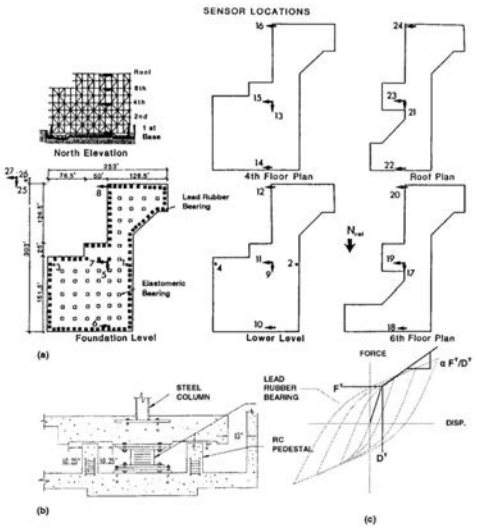


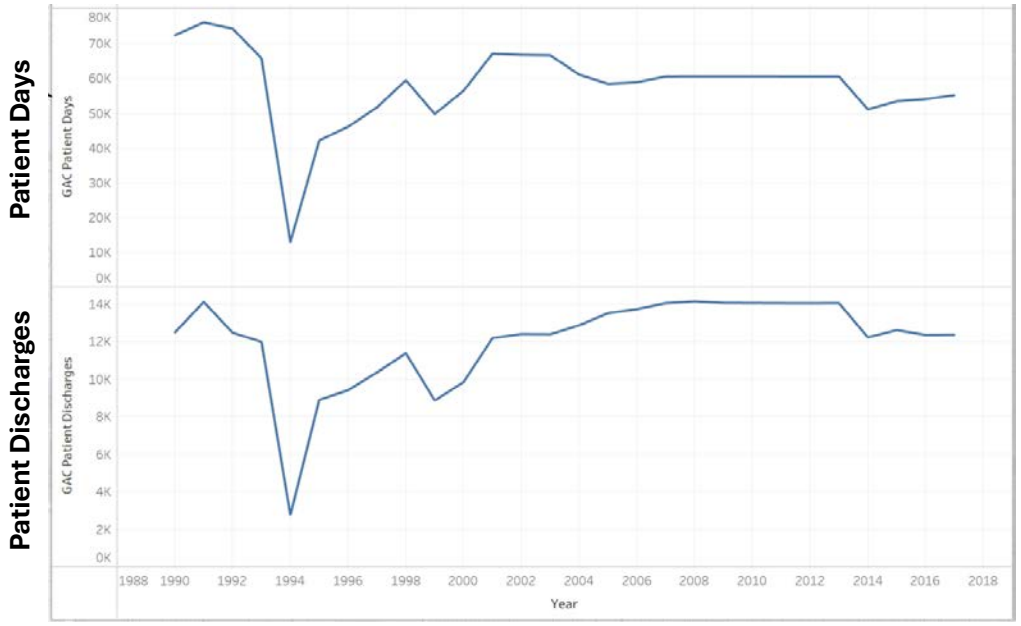
FIG. 1. USC Hospital Building (1 ft = 0.3048 m; 1 in. = 2.54 cm): (a) Elevation, Plan, Sensor Locations; (b) Isolation System Details; (c) Smooth Bilinear Hysteretic Force-Displacement Loops of Lead-Rubber Bearing

M 6.7 - The 1994 Northridge Earthquake

Saint John's Hospital, Santa Monica

Saint John's Health Center – Replacement Hospital with elastomeric seismic isolation system

Saint John's Health Center
The Effect of the Northridge Earthquake on Hospital Functions



22

Fig. 1. Typical shape of a "Dog-Bone" connec

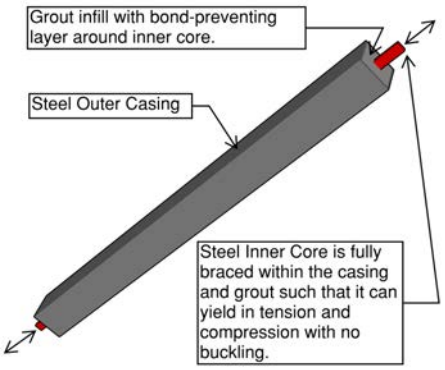
DOGBONE CONNECTION

- In the dogbone connection, portions of the beam flange near the beam-to-column connection are trimmed in order to enhance ductility under severe cyclic loads.

- The dogbone can be viewed as a ductile fuse. **It forces yielding to occur within the reduced section of the beam, an area that can sustain large inelastic strains.** At the same time, the dogbone acts as a fuse, limiting stress at the less ductile region near the face of the column.

23

BUCKLING RESTRAINED BRACED FRAME (BRBF)



Benefits:

1. Stable seismic behavior (i.e. - no buckling) allows the braces to absorb a significant amount of energy during cyclic loading.
2. The cost of individual BRB's is fairly inexpensive, opening the door for utilization of BRB's for a variety of project types.
3. Reduced overall building cost. Due to the improved seismic behavior of BRB's, code level seismic forces are significantly reduced for the entire structure. This reduction in force levels results in cost savings for framing elements, connections, and the foundation.
4. A variety of end connections are available, either to simplify construction installation or achieve a specific architectural appearance if the braces are exposed.

Applications of Fluid Viscous Dampers

Fluid viscous dampers can be used to provide protection during a seismic event. Fluid viscous dampers provide superior damping to just about any structure. By using viscous damping, the structures become velocity sensitive, rather than using hysteric damping which would make them displacement sensitive.

In addition, there are other types of dampers that also dissipate energy to avoid yielding of critical structural elements.

Senate Bill 1953 (SB 1953)

SB 1953 was introduced on February 25, 1994 and signed into law on September 21, 1994, and filed by the Secretary of State on September 22, 1994. The bill was an amendment to and furtherance of the Alfred E. Alquist Hospital Seismic Safety Act of 1983 (Alquist Act). SB 1953 (Chapter 740, 1994), is now chaptered into statute in Sections 130000 through 130070 of the Alfred E. Alquist Hospital Facilities Seismic Safety Act, and part of the California Health and Safety Code. The regulations developed as a result of this statute are deemed to be emergency regulations and became effective upon approval by the California Building Standards Commission and filing with the Secretary of State on March 18, 1998.

The Alfred E. Alquist Seismic Safety Act establishes a seismic safety building standards program under HCAI's jurisdiction for hospitals built on or after March 7, 1973. The Act was initiated because of the loss of life incurred due to the collapse of hospitals during the Sylmar earthquake of 1971. The Act emphasizes that essential facilities, such as hospitals, should remain operational after an earthquake. Hospitals built in accordance with the standards of the Act resisted the January 1994 Northridge earthquake with minimal structural damage, while several facilities built prior to the Act experienced major structural damage and had to be evacuated. However, certain nonstructural components of the hospitals did incur damage, even facilities built in accordance with the structural provisions of the Act. **The provisions and subsequent regulation language of Senate Bill (SB) 1953 amended the Act to address the issues of survivability of both nonstructural and structural components of hospital buildings after a seismic event. Therefore, the ultimate public safety benefit of the Act is to have general acute care hospital buildings that not only are capable of remaining structurally intact after a seismic event, but also capable of continued operation and provision of acute care medical services after a seismic event.**

Structural Performance Category (SPC)

All general acute care hospital buildings are assigned a Structural Performance Category (SPC) which measures the probable seismic performance of building structural systems. Building structural systems include beams, columns, shear walls, slabs, and foundations. SPC ratings range from 1 to 5 with SPC 1 assigned to buildings that may be at risk of collapse during a strong earthquake and SPC 5 assigned to buildings reasonably capable of providing services to the public following a strong earthquake. State law requires all SPC 1 buildings to be removed from providing general acute care services by January 1, 2020, unless an approved extension has been granted, and all SPC 2 buildings to be removed from providing general acute care services by January 1, 2030. A hospital facility meets the January 1, 2030 requirements if all the general acute care buildings on campus are SPC and NPC compliant (see NPC description). 2030 compliant SPC ratings are either SPC 3, 4, 4D, or 5. 2030 compliant NPC ratings is NPC 5.

SPC 1

These buildings pose significant risk of collapse and danger to the public.
Where the Office has performed a collapse probability assessment, buildings with Probability of Collapse greater than 1.20% shall be placed in this category.
Deadline: These buildings must be brought up to the SPC 2 level by January 1, 2008, or be removed from acute care service.
Exception: Buildings with an approved extension are permitted to provide acute care service only up to the length of extension granted. Maximum extension that may be granted per statute is January 1, 2020, beyond which the building can no longer provide general acute care services.

(California Administrative Code, Chapter 6, Table 2.5.3)

SPC 2

These buildings do not significantly jeopardize life, but may not be repairable or functional following strong ground motion.
Where the Office has performed a collapse probability assessment, buildings with Probability Collapse less than or equal to 1.20% shall be placed in this category. Buildings in this category are in compliance with the pre-1973 California Building Standards Code or other applicable standards, but not in compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act.
These buildings must be brought into compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act, its regulations or its retrofit provisions by January 1, 2030, or be removed from acute care service.

(California Administrative Code, Chapter 6, Table 2.5.3)

SPC 3

These buildings may experience structural damage which does not significantly jeopardize life, but may not be repairable or functional following strong ground motion.
These buildings are in compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act, utilizing steel moment-resisting frames in regions of high seismicity as defined in Section 4.2.10 and constructed under a permit issued prior to October 25, 1994. Buildings in this category will have been constructed or reconstructed under a building permit obtained through HCAI.
These buildings may be used to January 1, 2030, and beyond.

(California Administrative Code, Chapter 6, Table 2.5.3)

SPC 4

These buildings are in compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act, but may experience structural damage which may inhibit ability to provide services to the public following strong ground motion. Buildings in this category will have been constructed or reconstructed under a building permit obtained through HCAI.
These buildings may be used to January 1, 2030, and beyond.

(California Administrative Code, Chapter 6, Table 2.5.3)

SPC 4D Regulations

SPC 4D is a Structural Performance Category that was introduced into the 2019 California Building Standards Code, which allows noncompliant buildings to go past the 2030 seismic compliance deadline.

Retrofitting SPC 1/SPC 2 buildings to the highest standard, SPC 5, would essentially require existing buildings to meet current code. This can be prohibitively expensive in most cases, and impossible in some others. Rather than requiring SPC 1 and SPC 2 buildings to retrofit to SPC 5, now such buildings can retrofit to SPC 4D. SPC 4D allows retrofit to a structural standard that is equivalent, similar or comparable to SPC 4 buildings, which are already approved to provide acute care services beyond 2030. SPC 4D is a voluntary program that will primarily be used to retrofit SPC 2 buildings. The retrofit work will need to be completed by 2030 to allow acute care services to remain in the existing noncompliant buildings beyond the statutory deadline of 2030. It contains no milestones or other due dates.

SPC 5

Buildings in compliance with the structural provisions of the Alquist Hospital Facilities Seismic Safety Act and are reasonably capable of providing services to the public following strong ground motion. Buildings in this category will have been constructed or reconstructed under a building permit obtained through HCAI.
These buildings may be used without restriction to January 1, 2030, and beyond.

(California Administrative Code, Chapter 6, Table 2.5.3)

Non-Structural Performance Category (NPC)

All general acute care hospital buildings are assigned a Non-Structural Performance Category (NPC) which measures the probable seismic performance of building contents, equipment, and systems critical to patient care. Non-structural contents, equipment and systems include cladding, partitions, ceilings, equipment, pipes, conduits, ducting, furnishings, contents, elevators, stairs, as well as water, sewage, medical gases, and other mechanical and electrical systems. NPC ratings range from 1 to 5 with NPC 1 assigned to buildings where equipment and systems critical to patient care may be completely non-functional following a strong earthquake and NPC 5 is assigned to buildings where equipment and systems critical to patient care are reasonably capable of providing services to the public following a strong earthquake or other disaster. The NPC requirements, unlike SPC requirements, are cumulative, so a building meeting NPC 5 would also meet NPC 1, 2, 3, and 4D or 4. A hospital facility meets the January 1, 2030 requirements if all the general acute care buildings on campus are SPC and NPC compliant (see NPC description). 2030 compliant SPC ratings are either SPC 3, 4, 4D, or 5. 2030 compliant NPC ratings is NPC 5.

NPC 1

Buildings with equipment and systems not meeting the bracing and anchorage requirements of any other NPC rating.

(California Administrative Code, Chapter 6, Table 11.1)

NPC 2

The following systems are braced or anchored in accordance with Part 2, Title 24:
- Communication systems,
- Emergency power supply,
- Bulk medical gas systems,
- Fire alarm systems, and
- Emergency lighting equipment and signs in the means of egress

Deadline: January 1, 2002

(California Administrative Code, Chapter 6, Table 11.1)

NPC 3 / NPC 3R

The building meets the criteria for NPC "2" and in critical care areas, clinical laboratory services spaces, pharmaceutical service spaces, radiological service spaces, and central and sterile supply areas, the following components meet the bracing and anchorage requirements of Part 2, Title 24:
•Nonstructural components, listed in the 1995 CBC, Part 2, Title 24, Table 16A-0.

Exception: For NPC 3R, lateral bracing of suspended ceiling systems may be omitted in rooms with a floor area less than 300 square feet, provided the room is not an intensive care or coronary care unit patient room, angiography laboratory, cardiac catherization laboratory, delivery room, operating room or post-operative recovery room.
•"Equipment," as listed in the 1995 CBC, Part 2, Title 24, Table 16A-0, "Equipment," including equipment in the physical plant that service these areas.

Exceptions: Seismic restraints need not be provided for cable trays, conduit and HVAC ducting. Seismic restraints may be omitted from piping systems, provided that an approved method of preventing release of the contents of the piping system in the event of a break is provided. Only elevator(s) selected to provide service to patient, surgical, obstetrical and ground floors during interruption of normal power need to meet the structural requirements of Part 2, Title 24.
•Fire sprinkler systems comply with the bracing and anchorage requirements of NFPA 13, 1994 edition, or subsequent applicable standards.

Exception: Acute care hospital facilities in both rural area as defined by Section 70059.1, Division 5 of Title 22 and Seismic Zone 3 shall comply with the bracing and anchorage requirements of NFPA 13, 1994 edition, or subsequent applicable standards by January 1, 2013.
Deadline: January 1, 2008 unless the building has an approved extension or exemption.

(California Administrative Code, Chapter 6, Table 11.1)

NPC 4

The building meets the criteria for NPC "3" and all architectural, mechanical, electrical systems, components and equipment, and hospital equipment meet the bracing and anchorage requirements of Part 2, Title 24.
Deadline: January 1, 2020 or 2030 depending on the Seismic Design Category and extension request requirements.

NPC 5

The building meets the criteria for NPC "4" and onsite supplies of water and holding tanks for sewage and liquid waste, sufficient to support 72 hours of emergency operations, are integrated into the building plumbing systems in accordance with the California Plumbing Code. An onsite emergency system as defined in the California Electrical Code is incorporated into the building electrical system for critical care areas. Additionally, the system shall provide for radiological service and an onsite fuel supply for 72 hours of acute care operation.
Deadline: January 1, 2030

(California Administrative Code, Chapter 6, Table 11.1)

Status of Individual Hospital Compliance

HCAI/ OSHPD has a facility detail page with the associated building list page for most current data for any facility at the following web address:

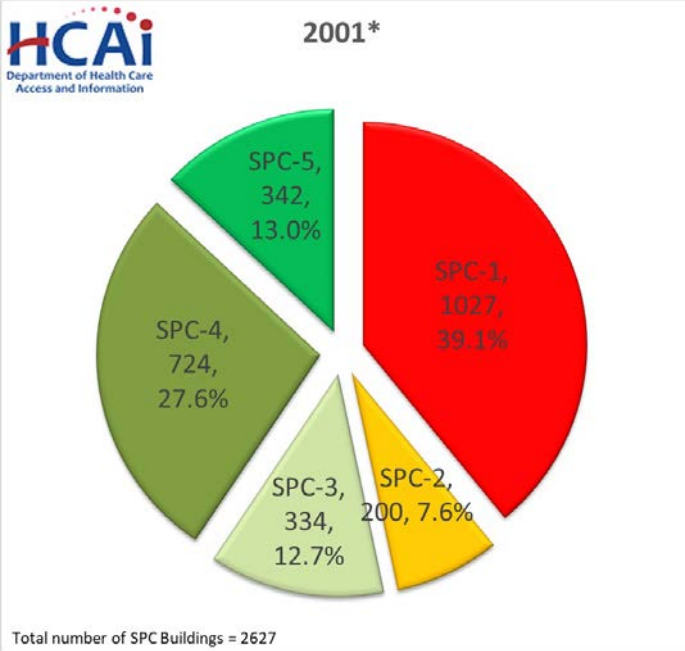
https://hcai.ca.gov/facilities/building-safety/facility-detail/

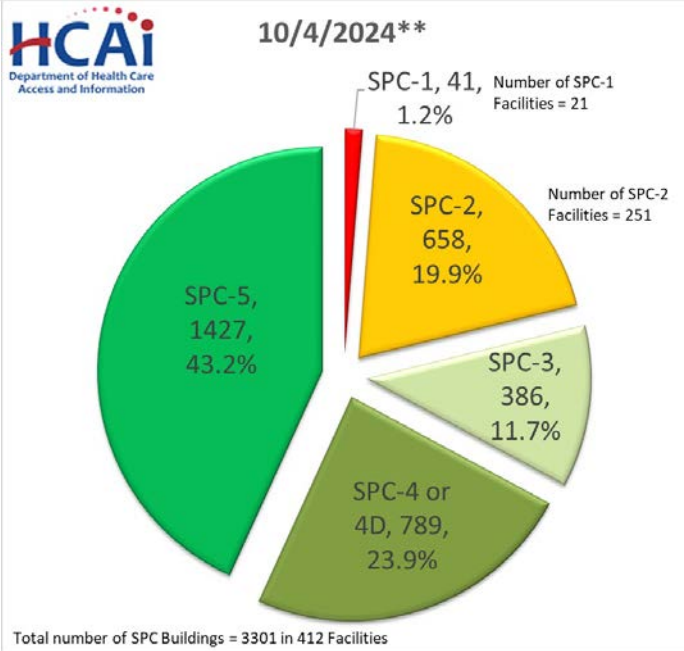
11760 Kaiser Foundation Hospital - Los Angeles

Bldg Num	Bldg Name	Classification & Status	RACs Date	NPC Status	Building Code	Year Built	Stories	Height in Feet	Instrumented	Construction Type	Sprinklered	AB1882 Signage	
BLD-01707	Centrex Building	OSHPD 1, In Service		1/1/2030 * NPC 4/4D Rpt: Review Completed; Sub Date:4/11/2023 NPC 5 Rpt: Review Completed; Sub Date:12/15/2023	1967 City of Los Angeles (COLA)	1969	2	29	No			Pending	SPC: 4 NPC: 2
BLD-02792	LAMC Hospital - Phase I	OSHPD 1, In Service		1/1/2030 * NPC 5 Rpt: Review Completed; Sub Date:12/15/2023	1998 California Building Code (CBC)	2014	7	99.37	Yes	Type I A (Type I Fire Resistive)	Fully	Pending	SPC: 5 NPC: 4
BLD-02793	Central Utility Plan - 1550 Edgemont	OSHPD 1, In Service		1/1/2030 * NPC 5 Rpt: Review Completed; Sub Date:12/15/2023	1998 California Building Code (CBC)	2009	2	44	No			Pending	SPC: 5 NPC: 4
BLD-07038	Pedestrian and Utility Passageway	OSHPD 1, Tunnels		1/1/2030 * NPC 5 Rpt: Review Completed; Sub Date:12/15/2023	1998 California Building Code (CBC)	2009	1	Unknown	No			Pending	SPC: N/A NPC: 4

As of early October 2024

The Status of SB1953 Compliance





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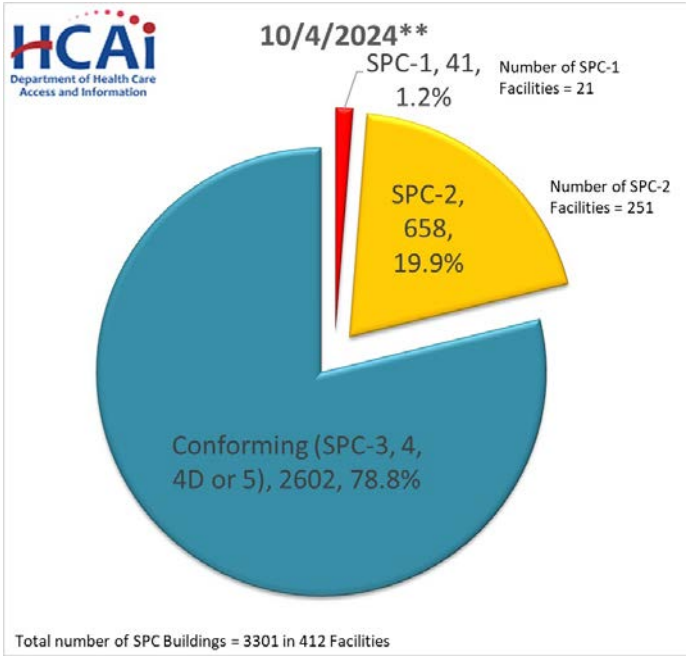
The Status of SB1953 Compliance



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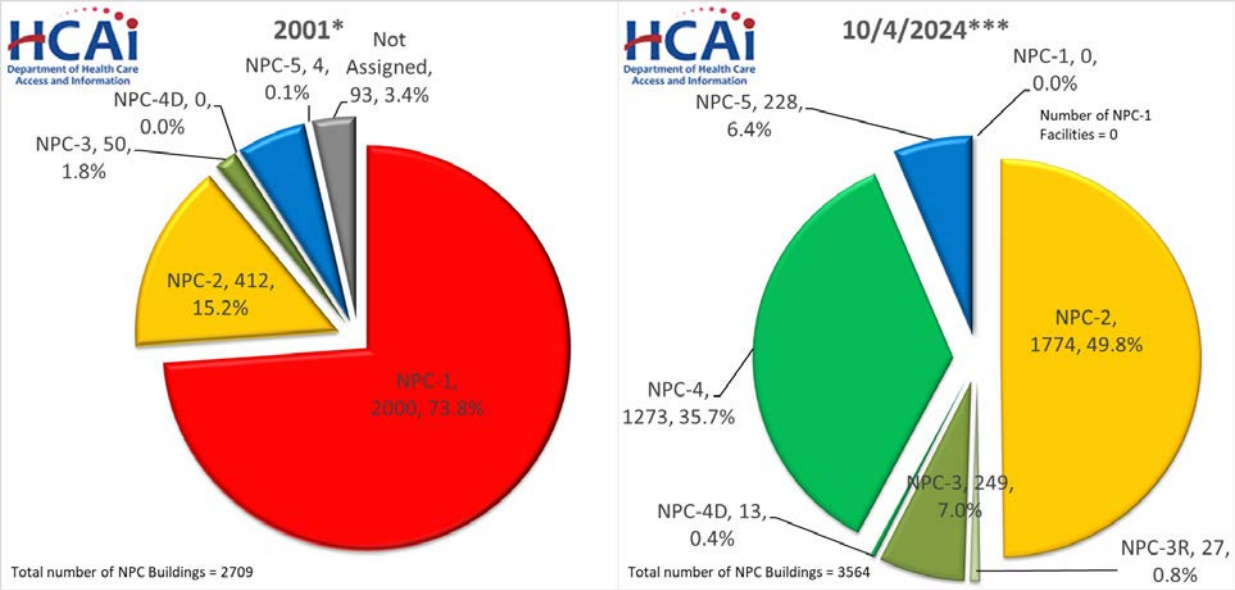
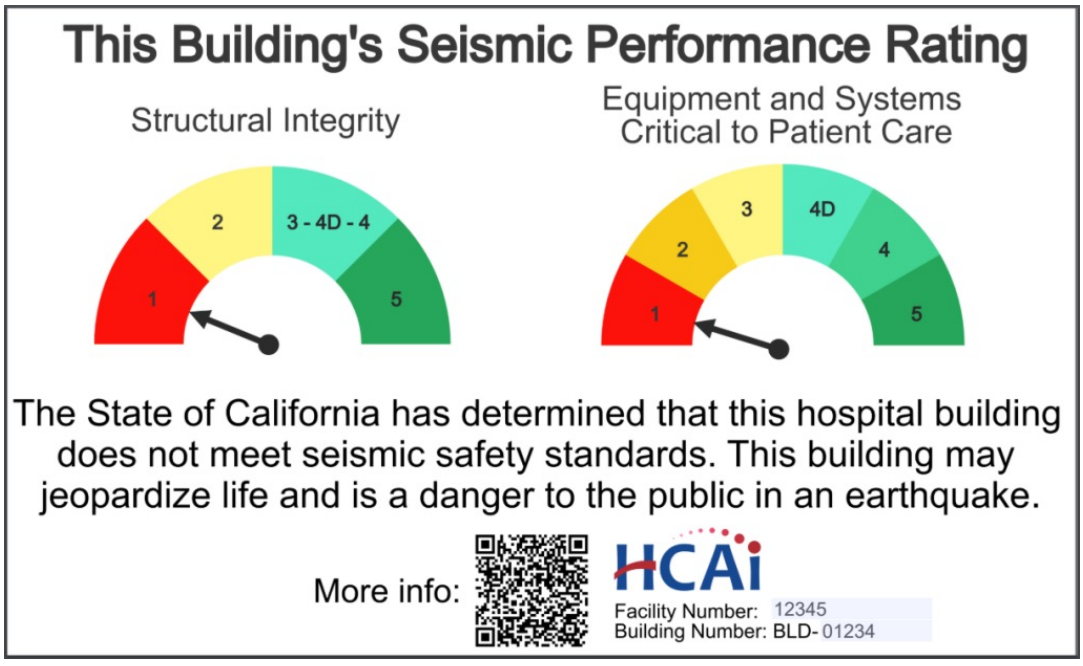
The Status of SB1953 Compliance



***Includes buildings under construction, tunnels and equipment yards (nonbuilding structures not included). Buildings under construction or just built are assigned a preliminary NPC of 4



A sign will be posted in each acute care building in California to inform the public about structural and non-structural conditions

LATEST UPDATES:

SB 1432, as amended, Caballero. Health facilities: seismic standards. Existing law, the Alfred E. Alquist Hospital Facilities Seismic Safety Act of 1983, establishes, under the jurisdiction of the Office of Health Care Access and Information, a program of seismic safety building standards for certain hospitals constructed on and after March 7, 1973. Existing law requires that, by January 1, 2030, owners of these hospitals must either demolish, replace, or change to nonacute care use all hospital buildings that are not in compliance with these standards or seismically retrofit all acute care inpatient hospital buildings so they are in substantial compliance with these standards, unless subject to an abeyance. This bill would authorize a hospital owner or operator to submit an application, by specified dates, to the department for additional extensions to the compliance deadline. The bill would require the department to grant or deny an extension of the deadline for substantial compliance with seismic safety regulations or standards up to January 1, 2035. The bill would require the application to contain a seismic compliance plan, a specified evaluation report, a financial plan, and an attestation to the department that the appropriate governing board of that hospital is aware that the hospital building is required to be in substantial compliance with the seismic safety regulations or standards.

Note: the SB 1432 was approved by the State Assembly and Senate in August 2024 and was vetoed by Governor Newsom on September 12, 2024. Bill returned to Senate.

SB1953 is proving to be a successful program in the development of Seismic Safety and Resilient Health Care Communities in California

Many thanks to Chris Tokas, Deputy Director of HCAI for his support and encouragement.

Appreciation is also extended to Drs. Roy Lobo and Hussain Bhatia of HCAI for providing the latest data on SB1953 compliance.

Thank you for your kind attention and your tenacious commitment to Seismic Safety and Resilient Communities

The Northridge Earthquake - 30 Years Later

A Catalyst for Engineering Resilient Communities

Webinar Series

Q&A

The recording of today's webinar will be posted within a week at

EarthquakeCountry.org/northridge30-webinar6

and SoCal.EERI.org

48

The Northridge Earthquake - 30 Years Later

A Catalyst for Engineering Resilient Communities

2024 Webinar Series

Episode 7: Lessons learned about business losses and economic recovery – The Northridge Earthquake as a catalyst for research and application

November 13, 12-1pm | Register: EarthquakeCountry.org/northridge30-webinar7

Kathleen Tierney, professor emerita, University of Colorado Boulder

Dr. Cynthia Kroll, regional economist

49