Chile Earthquake of February 27, 2010
Reconnaissance Report on Hospitals

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Talca Regional Public Hospital, Talca, Chile, March 19, 2010

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Goals of Hospital Team

- Assess the physical and medical similarity of Chilean Hospitals to US practice.
- Identify vulnerabilities that can
  - Threaten patients
  - Reduce the ability to provide emergency medical care
- Develop a protocol to collect detailed data measuring effectiveness and vulnerabilities of regional medical care.
  - Size and other medical characteristics of facility
  - Numbers of in-patients present, injured, evacuated, moved to other facilities
  - Numbers of outside patients treated

Chilean Hospital System

- Public Health System
  - Regional (we covered parts of 4 regions)
- ACHS
  - Began to provide care similar to Workman's Comp
  - Now essentially a hospital system
- Private hospitals and clinics
  - Catolica, etc.
- Systematic listing of facilities, damage, etc, available only on Public Health System.
  - Several other hospitals visited in Santiago

Overall performance of Public Health Hospital System according to Ministry of Health Website

- Total in shaken region: 100
- 17 to be completely rebuilt
- 8 with major damage
- 54 requiring minor repair
- 21 apparently undamaged

Reconnaissance of Hospitals

- Santiago area
  - Military Hospital
  - San Carlos Catolica Clinic
  - ACHS (Trahabador)
  - Victor Bulnes (Santiago Sotero del Rio, Felix Bulnes)
- Talca Regional Public
- Los Angeles Regional Public
  - Six satellite facilities
    - de Hupiel
    - Laja
    - Santa Barbara
    - Nacimiento
    - Yumbel
    - Mulchen
- Concepcion Regional Public
  - Talcahuano

Structural Systems

- Typical systems
  - Masonry bearing wall—only in very old buildings
  - Concrete Frame with infill
  - Concrete frame
  - Concrete frame with concrete shear wall
  - Steel brace frame-3 story (tube columns and braces)
- Structural Performance
  - Lack of damage to one story hospital buildings compared to high rise non-hospital concrete buildings suggests different input energy levels.
  - Older buildings beat up—often masonry
  - Mid-rise hospital buildings constructed after 1985 generally performed well structurally, with some exceptions.
  - Seismically isolated buildings (3) performed well but joint damage was common.

Nonstructural Systems

- Systems used are very comparable to US practice
- Only the newest hospitals in Chile have systematic seismic protection for nonstructural systems
- The nonstructural seismic performance observed should be expected in similar levels of ground motion in older US hospitals or where code-specified nonstructural protection is not enforced.
  - 0.2-0.25 g in Santiago
  - Higher, up to 0.5 g elsewhere
  - Effects of long duration on nonstructural systems has not been studied.

Organization of Findings

- By issues known to affect patient safety or functionality
  - Communications
  - The need for evacuations
  - Elevators
  - Loss of power
  - Loss of water
  - Water damage
  - Loss of bulk oxygen tanks
  - General disruption from ceiling damage
  - General disruption from nonstructural masonry damage
  - Disruption to fragile areas like paper medical records, pharmacies, and laboratories
  - Damage to medical equipment
  - Damage to MEP equipment
  - Damage to MEP distribution systems

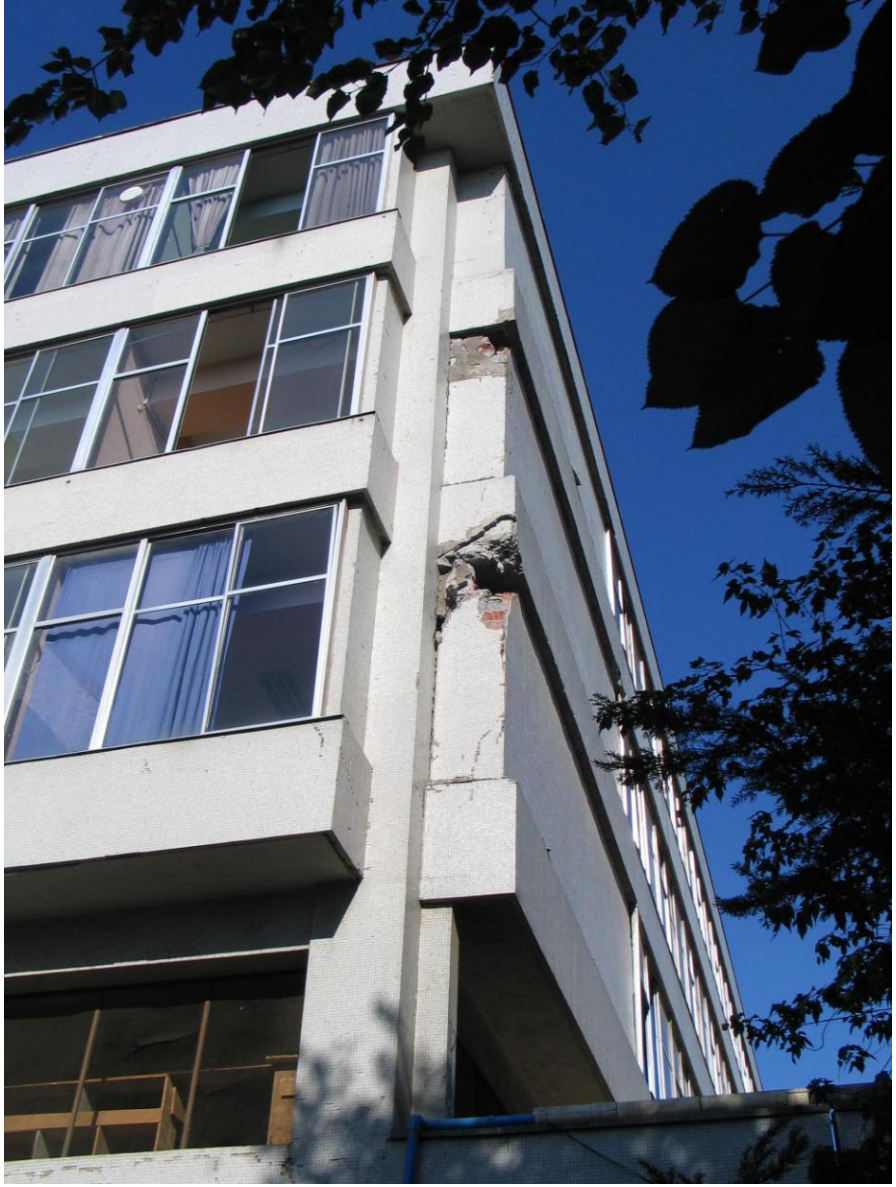
Known Hospital Seismic Issues

- **Communications**
  - Over-reliance on cell phones, no plan for emergency communication in facility or between facilities—particularly to headquarters of public health system.
  - Perhaps explains remarkable self reliance at each site
  - Administrators interviewed wanted to address this issue for future emergencies

Evacuations

- San Carlos de Catolica (Santiago)
  - Fifth floor of fixed base wing due to nonstructural chaos
- Felix Bulnes (Santiago)
  - 200 patients from tower due mostly to nonstructural but also damage to infill masonry
  - Administrative building severely damaged, and would have caused casualties if occupied.
  - Entire facility is now closed. Clinic building under construction/renovation is being rushed to completion

Patient room. Felix Bulnes



Felix Bulnes

Evacuations

- Talca
  - Older light concrete frame with heavy masonry severely damaged and evacuated
  - Chilean military hospital set up across street is still in operation.
- Los Angeles
  - Older buildings slated for replacement in 3 years evacuated due to nonstructural, infill, and water damage
  - Several floors of newer building evacuated for repairs
- Concepcion
  - Older building evacuated due to water and sanitation piping systems leaks


HOLY CROSS MEDICAL CENTER

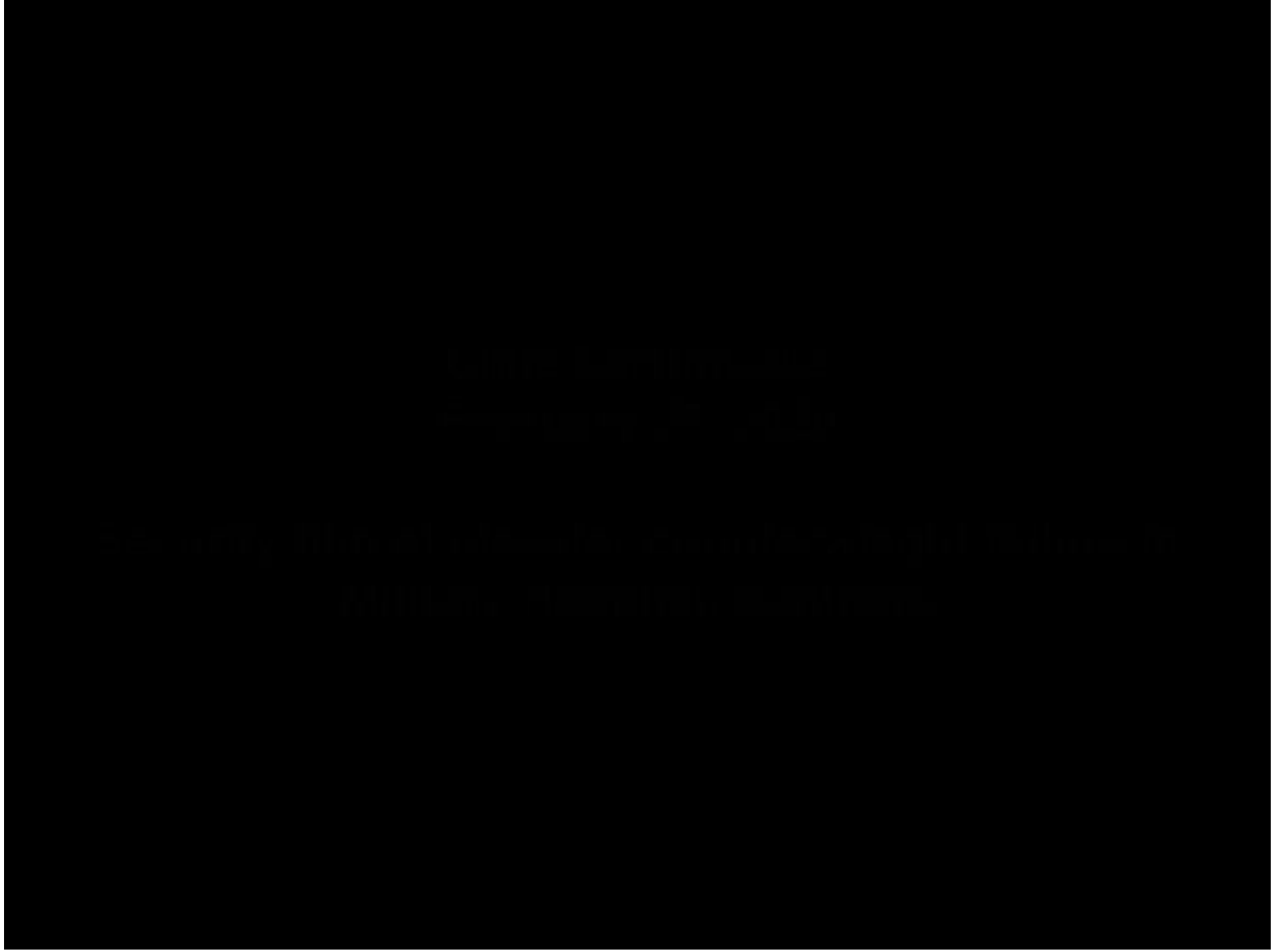
Evacuated building at Talca Hospital

Evacuated building at Los Angeles Hospital

Known Hospital Seismic Issues

- **Elevators**
  - Significant failures. Over 50% of all elevators were out, most due to counterweights off rails.
  - In every building evacuated, elevators were inoperable, requiring patients to be carried down stairs-often rubble strewn.
  - Elevator machine rooms and shafts are typically accessible only by elevator maintenance service or one person on site.
  - Evacuations required use of stairs.

Anchor bolt failure of elevator generator set due to inadequate edge distance.
Los Angeles Regional Public Hospital



Security camera at Military Hospital (Santiago) captures counterweight failure

Known Hospital Seismic Issues

- **Loss of Power**
  - Outside power lost for various times at every facility
  - Seldom caused an ongoing problem due to availability of emergency generators and at least 3 days fuel.
- **Loss of Water**
  - Unlike most of the US, many sites had on-site storage for 3 or more days (or wells).
  - Water provided that was not pumped through facility system did not provide sufficient pressure for toilets and some medial equipment.

Known Hospital Seismic Issues

- **Damage/disruption from water**
  - Not statistically frequent but caused at least three buildings to be evacuated, and shut down 3 of 6 ORs in relatively new building.

2005 building; Los Angeles Hospital. Infill masonry wall collapses on to distilled water equipment, spilling two 150 gallon containers; water leaks past perimeter edge of slab to OR suite below, closing 3 or 6 ORs

Continuing water damage at Talca Hospital. Water is leaking from water heater on right. Building was closed due to nonstructural damage, dominated by water.

Known Hospital Seismic Issues

- **Bulk oxygen storage tanks**
  - Standard of practice is to anchor. No overturning reported, but close calls….

Oxygen tank legs punched through support slab but did not overturn and remained functional.
Felix Bulnes-Santiago

Overturning tension stretched anchor bolts. Talcahuano Hospital.

Known Hospital Seismic Issues

- **Suspended lay-in ceilings**. Generally without any seismic detailing. The “American Ceiling”
  - Most consistent failure.
  - Often causes little real damage but great fear and disruption.
  - Fallen light fixtures and air registers can be life safety issue
  - Older ceilings drop dust and other debris (in the US, often asbestos)

The story of the American Ceiling

The morning after. Los Angeles Hospital. Note fallen light fixtures and mechanical registers, in addition to ceiling panels.

Add clips to hold down tiles

Fallen tile despite clips. Talca Hospital.

Close up of clips used at Talca Hospital in new building.

ICU with perfect performance

ICU. Talca Hospital older building-evacuated

Packing tape is almost as good as duct tape as a cure-all!

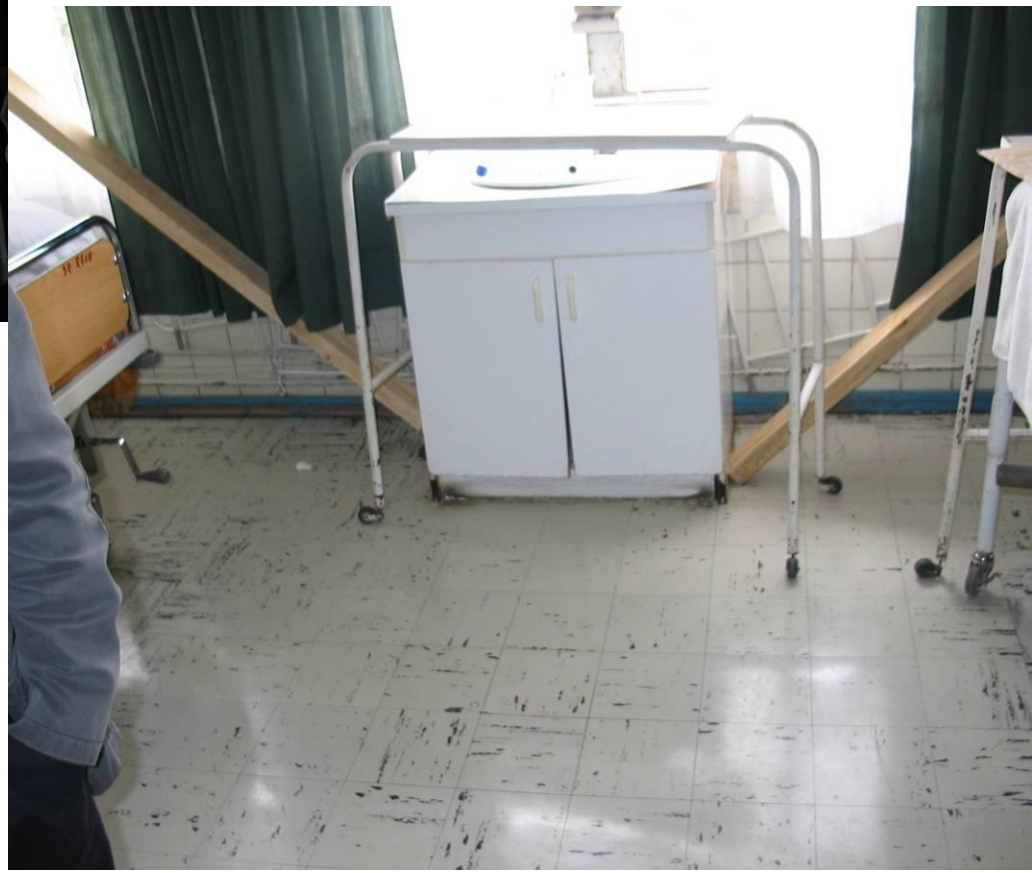
ICU Talca Hospital

Known Hospital Seismic Issues

- **Infill masonry/heavy partition damage**
  - Considered "nonstructural" but, like ceilings, causes fear, creates dust and occasionally risk of injury.

Cracked and spalled infill in patient room. Felix Bulnes (Santiago)

Temporary braces at loose precast partitions. Laja



Braces supported at bottom with cabinet

Known Hospital Seismic Issues

- **Vulnerable areas**
  - **Paper medical records, pharmacies, and laboratories**
  - **Medical Equipment**
  - **Mechanical/Electrical/Plumbing Equipment**
  - **Mechanical/Electrical/Plumbing Distribution Systems**

- Did not “stand out” as vulnerable. Damaged when building had other nonstructural damage

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