TABLE B7.2

Summary of Non structural Damage to Northridge, Olive View, and Holy Cross Medical Centers

Primary Cause of Disruption and Evacuation	Northridge	Olive View	Holy Cross
Broken piping, water leakage	x	x	x
Mechanical equipment damage, lack of HVAC service	x	x	x
Sprinkler and/or other water line breaks, leaks	x	x	x
HVAC equipment anchorage failures	x	x	x
Large oxygen tank base failures, leaning tanks	x	x	x
Toppling of unanchored cabinets and equipment caused localized evacuation for cleanup and repair	x	x	x
Communications failures	x	x	x
Elevator damage	x	x	x
Fire fighting system out	x	x	x
Medical gas failure		x	x
Backup power outage		x	
Water service outage	x	x	x
Gas service outage		x	x
Electrical service outage	x	x	x
Peak ground acceleration, free field	not instrumented	0.91g horizontal 0.60g vertical	not instrumented
Peak building acceleration	not instrumented	2.31g horizontal (roof)	not instrumented

Sources: OSHPD, 1994b; McGavin and Patrucco, 1994; Pickett, 1994; CDMG, 1994

- Though the structural damage to Holy Cross was not relevant to the actual functioning of the hospital in the earthquake's aftermath—it was not discovered until more than a month after the earthquake—the failure of heavy welded-steel moment-frame connections was significant. (The issue of special concerns with current code requirements for steel connections is covered in Background Report B16.)
- In the case of the main hospital at Olive View, the structural damage was limited to the penthouse. Design procedures for penthouses is an

issue being addressed by OSHPD and is too detailed to address at the policy level discussed here.

- Only the six post-1973 buildings at the Northridge Hospital site are considered below. Unlike Olive View and Holy Cross, the Northridge campus was mostly pre-Act in vintage.

At all three sites, the primary issue is the disabling amount of nonstructural damage, as shown in **TABLE B7.2**. For reference, peak acceleration values for the instrumented Olive View site and building are shown; the ground peak acceleration value for the VA Sepulveda hospital, which is nearer to the Northridge site, is also about 0.9g, and combined with the geographic pattern of damage in the Los Angeles area, these facts concerning ground motion provide a reasonable basis for selecting the following three facilities as those post-Act sites that were most heavily shaken.

PHOTOGRAPH B7.2 and **PHOTOGRAPH B7.3** illustrate large oxygen tank damage. Failure of one or more of the components at the base of the tank—legs, base plates, anchor bolts—is the recurring kind of damage. **PHOTOGRAPH B7.4** shows light fixture damage, as compared with **PHOTOGRAPH B7.5**'s successful performance of safety-wired lights. **PHOTOGRAPH B7.6** illustrates HVAC damage.

According to the daily census of Los Angeles County-wide hospital capacity (LAFD/EMS, 1994), at the peak of medical demand on January 17 there were 669 noncritical beds and only 136 critical-care spaces available in nonfederal hospitals. This amount of reserve would have been approximately doubled had Olive View and Holy Cross not been disabled. It is questionable whether the remaining facilities could have immediately served a large number of injuries. Treatment by portable emergency medical centers, mutual aid flowing into the region from elsewhere, freeing up capacity at local hospitals by early discharge of patients and cancellation of non-emergency appointments, or transportation of injured patients to more distant undamaged facilities might have been possible, but this has never been tested on such a scale in California. The effectiveness and rapidity of such "Plan B" measures is unknown. **PHOTOGRAPH B7.7** shows a red-tagged medical facility.

Structural Performance of Pre-Act Buildings

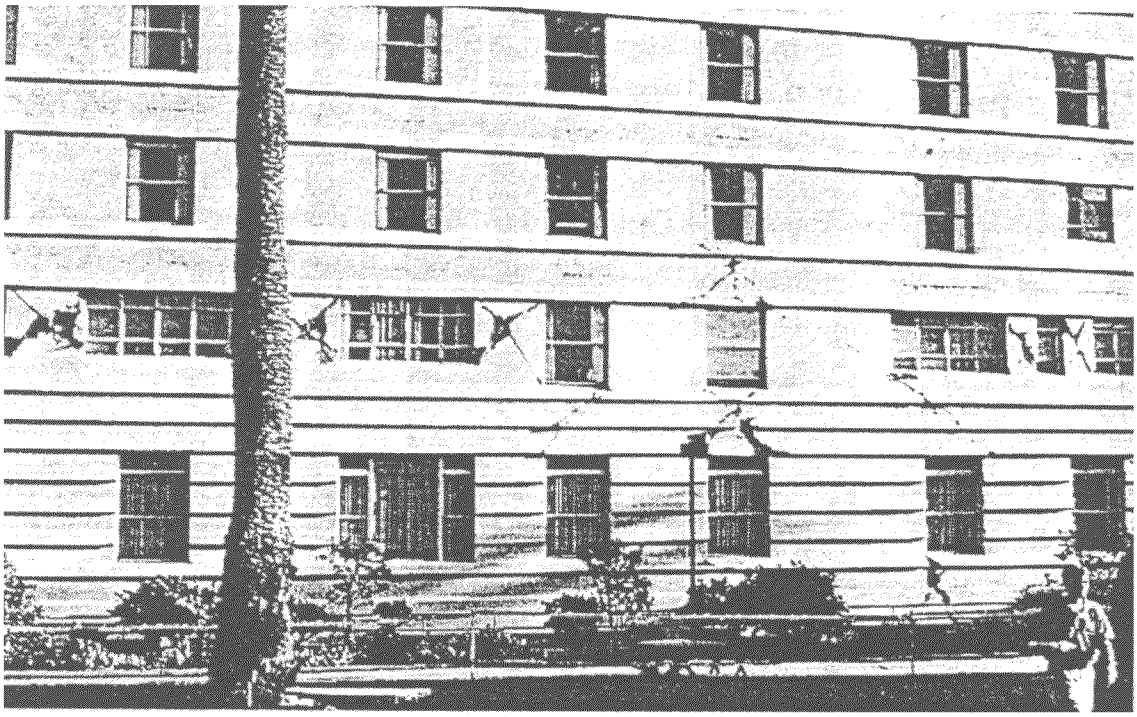
Structural damage was definitely greater to pre-Act buildings, mirroring general trends in the earthquake resistance of post-mid-'70s versus pre-mid-70s construction. As shown by the performance of two dozen Veterans Administration Sepulveda buildings that were designed in 1952, many of which experienced only repairable cracking, good performance to older buildings is associated with reliable types of systems that have not greatly changed over the years (reinforced concrete and reinforced masonry shear walls) and with regular configurations (Degenkolb Associates, 1994). Moment-resisting frame design and construction, especially of reinforced concrete, has changed much more since about the time of the San Fernando earthquake in 1971, and this is reflected in the damage tabulated above. Because of the higher quality-control standards of state-regulated hospital construction, it is likely that structural performance was aided by the Hospital Act's requirements. **PHOTOGRAPH B7.8** illustrates some of the more serious damage in the earthquake to the pre-Act St. John's Hospital in Santa Monica. Collapses of medical office buildings and parking structures at hospitals (see **PHOTOGRAPH B7.9**), while outside the scope of the Act, are related to the safety and functionality of healthcare facilities.

Structural Performance of Post-Act Buildings

Except for the steel-frame connections at Holy Cross Medical Center, the structural performance of post-Act buildings was excellent. While the steel-frame-connection issue is significant, it is being addressed in a separate background paper; there is nothing unique about hospital steel frames that needs to be separately discussed here. Penthouse performance is a concern that can be addressed with minor modifications to OSHPD procedures without basic policy changes.

Nonstructural Performance of Pre-Act Buildings

Non structural damage in pre-Act buildings was significantly greater than in post-Act buildings, though the contrast in performance is not so striking as in the case of the structures.



PHOTOGRAPH B7.8: Structural damage that caused "red tag" safety assessment and closure of building, St. John's Hospital, Santa Monica. *photo credit: Marvin Hollings, Earthquake Engineering Research Institute*

Nonstructural Performance of Post-Act Buildings

Widespread temporary outages were caused by nonstructural damage in newer hospitals built to Hospital Act requirements. Perhaps at the top of the list is water-related components: damage caused by leakage from sprinkler, domestic water, and chilled water lines, as well as water outages and lack of sufficient onsite storage. The fact that two of the largest and newest facilities in the San Fernando Valley, Olive View and Holy Cross, were effectively shut down for the week of the earthquake by nonstructural damage is troubling and raises issues about whether the Act's aim to provide functional hospitals is being met

Communications among hospitals and emergency services agencies were disrupted in this earthquake. This disruption extended beyond the expectable telephone outages to include radio lines of communication that are often relied upon as the basic mode in earthquakes.

> During the initial roll call of hospitals on the H.E.A.R. (Hospital Emergency Administrative Radio) system beginning immediately after the quake, there was only a 29 percent response and no response from any hospitals in the most impacted area....HEAR is dependent on land lines and this could have been a primary cause of the disruption. The Reddi-Net computer system was said to have been 90 percent functional by the Hospital Council but again the hospitals in the impacted area did not receive any messages on the system. (Cheu, 1994, p 4-5)