

## DAMAGE TO CRITICAL FACILITIES

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**C**ritical facilities planned to be visited during the one-day reconnaissance tour included hospitals, schools, police stations and other public buildings. While we had opportunities to inspect damage in some of these structures, due to time limitations, it was decided to concentrate our efforts on hospitals. Three hospitals were chosen for their strategic value, extent of damage, and human and economic impact.

### INVENTORY

According to available information, there are 4,375 health care facilities within the six-county seismic affected zone, of which 165 are hospitals. Some suffered significant nonstructural as well as structural damage.

### HOSPITALS VISITED

The three hospitals chosen for more in-depth site visits were: the Christian Hospital and the Veterans Hospital in Puli, and Shiu-Tuan Hospital in Tsushan. All three are major health care facilities in their respective cities. The observations described below are based on interior as well as exterior damage inspections and on interviews with hospital officials.



*Figure 1. The Christian Hospital sustained considerable damage. Photos show (left) part of the exterior damage to the hospital; and (above) interior damage to partitions and ceilings.*



*Figure 2. The first floor of the Christian Hospital remained open though the hospital suffered extensive interior damage.*

### CHRISTIAN HOSPITAL

A major facility in Puli and surrounding communities, the Christian Hospital is a 400-bed facility of reinforced concrete (RC) construction consisting of a new (about 4-yr. old) section and an old (about 20-yr. old) section (see Figure 1).

#### Damage

- New section sustained considerable damage from the main event on 9/21/99. Out of safety concerns primarily due to nonstructural damage (power outage<sup>1</sup>, water damage, equipment failure, etc.), the building was evacuated with patients housed in tents on the hospital ground. The building was immediately inspected and considered safe. Upon interior cleaning, patients were returned to the building.
- The building suffered significant nonstructural damage again from the 9/27/99 M6.8 aftershock. Patients were again evacuated and housed in temporary trailers with considerably reduced capacity (about 50 beds), with overflow transferred to other area hospitals.
- The first floor of the building remains open and is being used for emergency care, patient registration and processing, command post, etc. (see Figure 2).

#### Consequences and Impact

- A major part of the hospital is non-serviceable primarily due to nonstructural damage.
- Drastically reduced capacity (10% of original) at a time when demand was the highest.
- Trauma to patients through two relocations.
- Drastically reduced services due to equipment damage.

<sup>1</sup>The emergency generators also failed. They were located on the second floor of a separate building and, due to amplified acceleration on that floor, major components broke loose and rendered them inoperable.

- The lack of an earthquake emergency management plan probably made the situation worse.

### Restoration

Restoration is underway. It was estimated that the interior will be restored and serviceable in two weeks.

## VETERANS HOSPITAL

Another major hospital in Puli, the Veterans Hospital is a 450-bed facility with two main RC buildings (the Medical Center and the Administration Center), built about three years ago and several older (about 25-yr. old) and smaller buildings (see Figures 3 and 4).

### Damage

- New buildings sustained considerable damage from the main event. The Medical Building (Bldg. 1) was closed and the patients in the Administration Building (Bldg. 2), along with those in Bldg. 1, were either moved to the older buildings or transferred to other VA hospitals. About 220 patients remain at the hospital.
- Considerable nonstructural damage in Bldgs. 1 and 2, including power failure, water damage, and equipment damage was observed. Bldg. 1 also sustained considerable structural damage, probably due to a lack of ductile detailing.

### Consequences and Impact

- A major part of the hospital is non-serviceable due to both structural and nonstructural damage.
- Drastically reduced capacity (50% of original) at a time when demand was the highest.
- Trauma to patients due to evacuation.



Figure 3. An overview model of the Veterans Hospital in Puli. The two white buildings are the newest and both sustained considerable damage.



Figure 4. The Veterans Hospital sustained both exterior damage (above) and interior damage (left) to the newest buildings of the medical center.

- Drastically reduced services due to equipment damage.
- As in the case of the Christian Hospital, no earthquake emergency management plan appeared to be in place at the time of the earthquake.

### Restoration

Whether Bldg. 1 is to be demolished or repaired remains to be determined. Bldg. 2 is expected to be repaired within two weeks.

## SHIU-TUAN HOSPITAL

Shiu-Tuan Hospital is a 9-story, two-year-old RC building with a 400-bed capacity. It is privately owned and is the largest in Nantou County. The structure is situated about 120 m from the Tsa-Lung-Pu Fault with an uplift of approximately one meter at the site.

### Damage

- Structurally intact, it suffered considerable non-structural damage as in the case of the other two hospitals (see Figures 5 and 6). Interior damage was most severe at the second- and third-floor levels where, unfortunately, some of the major facilities, such as operating and recovery rooms, were located.



Figure 5. Interior damage in the Shiu-Tuan Hospital. Shown are (top) fallen brick inside the hospital and (right) a damaged interior glass brick wall.

Patients were moved to open hospital ground and subsequently transferred to other hospitals.

- Hospital closed.

### Consequences and Impact

- Trauma to patients due to evacuation and reallocation.
- Hospital closed, making the largest hospital in this vicinity unavailable to patients and earthquake victims.
- Seven patients died due to stoppage of life-support systems.

### Restoration

Repair is underway and the process may take one to two months. Funds for the repair remain to be found.



Figure 6. Damage to an exterior wall of the Shiu-Tuan Hospital in Nantou County.

## OVERALL OBSERVATIONS

The damage to the three hospitals and its impact underscore the importance of addressing nonstructural issues. Performance of nonstructural components could be substantially improved, with attendant damage reduction, using rather simple and inexpensive means.

## RECOMMENDATIONS FOR SHORT-TERM RECOVERY AND RESEARCH

- Review and improve current design and installation practices in nonstructural components.
- Develop effective retrofit strategies.
- Review and improve current nonstructural seismic provisions for hospitals and other critical facilities.